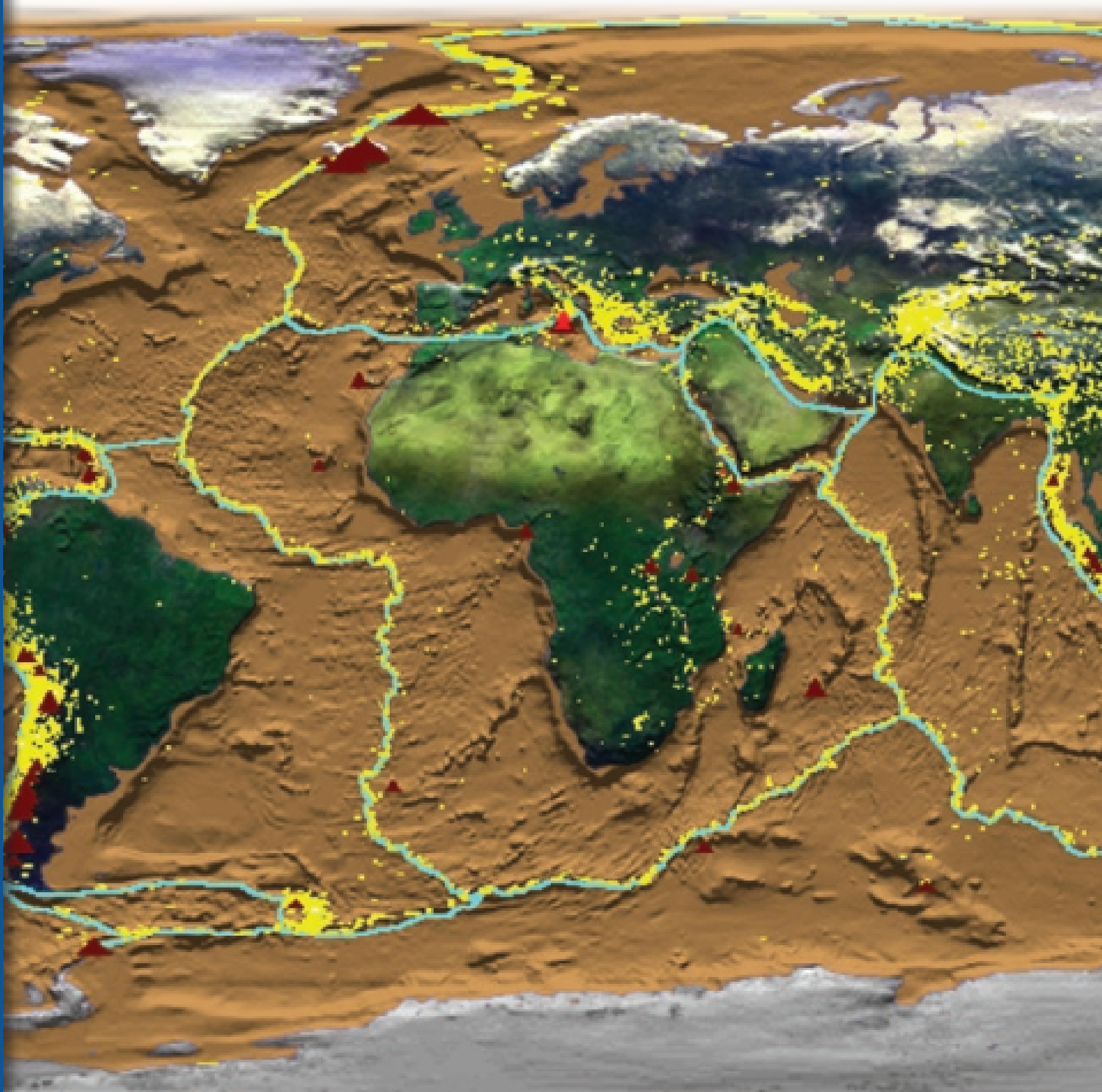
Unit 4

Plate Tectonics and Rock Cycling:

What causes Earth's surface to change?

Student Procedure Guide



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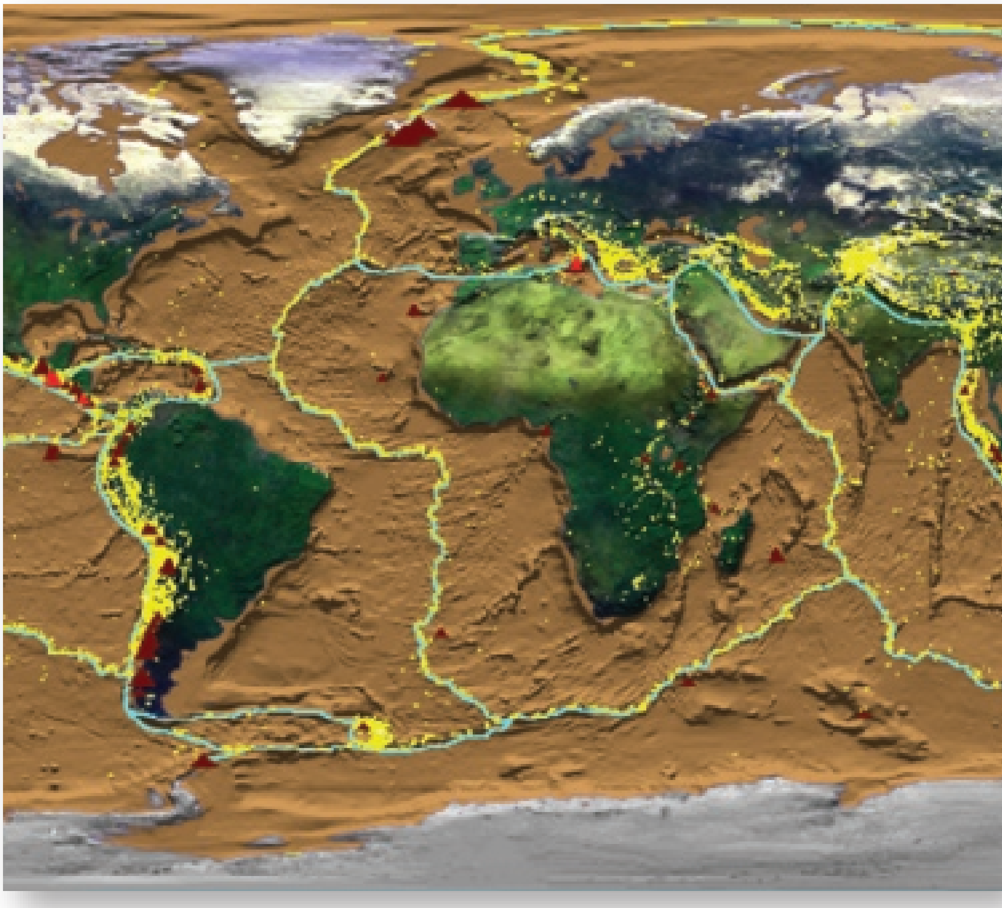

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Core Knowledge Science

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Plate Tectonics and Rock Cycling

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References

Readings

Lesson 1: What is causing Mt. Everest and other mountains to move, grow, or shrink?

An Interesting Phenomenon

Turn and talk

1. Read the headline on the slide.
2. Turn and talk with a partner about what could cause a mountain to grow.

With your class

3. With your class, locate Mt. Everest on the map.
4. Also as a class, find the location of your school/town and label it on the class map.

Read about Mt. Everest.

In your notebook

5. Make a Notice and Wonder chart in your notebook.
6. With a partner, read about Mt. Everest. Stop at the end of each paragraph and record your noticings and wonderings in your notebook.
7. Be ready to share with the class.

With your class

8. With your class, discuss:
    - What were some of the things you noticed about what happened to Mt. Everest?
    - What are some of your wonderings?

With a partner

9. Discuss the following:
    - Possible causes for the increase in elevation of Mt. Everest.
    - Possible causes for Mt. Everest moving to the northeast.

Develop an initial model.

On your own

10. You will develop a model for what you think are:
    - Possible causes for the increase in elevation of Mt. Everest.
    - Possible causes for Mt. Everest moving to the northeast.

With your class

11. Revisit norms and set a goal of a norm to focus on as the class develops the consensus model.

Class Consensus

With your class

12. With a class develop a consensus model to represent:

- Possible causes for the increase in elevation of Mt. Everest.
- Possible causes for Mt. Everest moving to the northeast.

Considering Other Mountains

With your class

13. There are a lot of other mountains in the world. Discuss with the class:

- What are some other mountains or mountain ranges you know about?
- Do you think they are changing in similar ways too?
- How could investigating other mountains and the range, or area they are part of, help us figure out what might be happening at Mt. Everest?

In your notebook

14. With your class, develop a data table like the one on the slide to use to record data about other mountains.

15. Think about:

- What are some types of data we would want about other mountains?

With your group

16. With your group, analyze the *Data Cards of Other Mountains and Mt. Everest.* Each person in your group should analyze a different mountain.

17. Be ready to report to your group:

- Are any other mountains changing either by elevation or location?
- Why might these other mountains be changing?
- What patterns do you notice between the different mountains?

Scientists Circle

18. Join your class in the Scientists Circle.

19. As a class, add the different locations to the map.

20. As a class, add data for each of the mountain locations that may be considered evidence of changing.

21. Look for patterns in the data with your class.

Add to initial model.

With a partner

22. With a partner using the handout from your teacher:

- Choose a location where the data shows that the mountain has been shrinking over time.
- Develop a model to represent what you think is causing this to happen.

Navigation

Turn and talk

23. Talk with a partner about:

- Why did we want to look at information about other mountains?
- What kind of data were we looking for?

With your class

If all mountains aren't growing, then our initial model won't explain what is happening to every mountain.

24. As a class, revise/add to the consensus model to include ideas for what could cause a mountain to shrink.

Related Phenomena

Think back on all your experiences you've had over your life where you noticed a change in the surface of the land or landforms. Consider all scales: these changes from the very small to the very large.

On your own

25. In your notebook, on the next blank page make a T-chart with the column headings, example and causes. Think about:

- What are other examples of where you have seen the size or shape of the land or landforms change over time?
- What do you think caused these changes?

With a partner

26. Share examples of where you have seen the size or shape of the land or landforms change over time.

27. Identify any causes for these that you think might also cause the size or shape of some mountains to change over time.

With your class

28. With your class, share examples of where we have seen the size or shape of the land or landforms change over time AND what we think the cause for this is that might also cause some mountains to change over time.

Navigation

In your notebook

29. In your notebook, write down any new questions you are thinking about after making our class consensus models.

Driving Question Board

With a partner

30. With a partner: Review the questions you brainstormed at the end of the last class.

31. Then write one question per sticky note. Write in marker, big and bold. Put your initials on the back in pencil. Be ready to share.

Scientists Circle

32. Gather in the Scientists Circle with your questions.

33. Be ready to share your questions.

Information and Data Needed

In your notebook

34. Think about what additional sources of data we might need to figure out the answers to our questions.

35. On a new page in your notebook, record your ideas for information we need and investigations we might want to carry out.

Scientists Circle

36. Take a moment to look at our questions on our DQB. Talk with your elbow partner in the Scientists Circle:

- What potential causes did we identify as a class for Mt. Everest changing? What seems the most likely cause to you and why?

Lesson 2: How are earthquakes related to where mountains are located?

Navigation

With your class

1. Last class we analyzed some data about Mt. Everest and other mountains across the world. Consider the following question as a class:
   - What about these different mountain cases were we trying to explain in our last lesson?

Correlation vs. Causation

With a partner

2. Look at the two words below. Think about when you have heard them used. Talk with a partner about what you think the two words mean, and what makes them different from each other.
   - Correlation
   - Causation

Discuss the words with a partner. Be ready to share your ideas with the class.

How can we narrow down our focus?

With your class

3. We have several potential causes that can lead to changes in our mountains. Consider the following questions:
   - What have we done in previous units when we have several potential causes that could explain observations in the phenomena we are investigating?
   - How did we investigate those variables to determine whether or not each variable could cause the observed changes, or whether they are just correlated (related to) with the changes?

Predictions About Earthquakes

Turn and talk

We read that in 2015, there was an earthquake on Mt. Everest and that other mountains also have had or still have earthquakes.

4. Turn and talk to a partner about the following questions:
   - What do you think you would see happening if you were on Mt. Everest during the 2015 earthquake?
   - Do you think it would provide enough evidence to support whether the earthquakes caused these mountains to increase in height and change locations?

With your class

5. Let's watch and listen to Dr. Jon Kedrowski's experience of the 2015 Mt. Everest earthquake.

Look at Ridgecrest, California.

In your notebook

6. Make a chart on a blank page on the left side of your science notebook to record what you notice and wonder from images taken after the 2019 earthquake in Ridgecrest, California.

7. Record what you notice and wonder about the following slides:
   - Video clip from the 2019 Ridgecrest, California earthquake
   - Image #1
   - Image #2
   - Image #3
   - Satellite views of Ridecrest, California
   - Colored satellite image

Be ready to share your ideas with the class.

Explore other earthquakes.

In your notebook

8. Make a claim in your notebooks:
   - Do you think earthquakes are causing **changes in mountain elevation**, or just correlated with the changes?
   - Do you think earthquakes are causing **changes in mountain location**, or just correlated with the changes?
   - What evidence do we have that supports your claims?
   - What additional data do we need to determine the validity of our claims?

9. Place the maps your teacher gives you sideways in your notebooks so that they are facing the same direction.

With your group

10. In your group, determine who will investigate the following:
    - How is Earthquake **Depth** Related to Where Mountains **Are Moving**?
    - How is Earthquake **Strength (Magnitude)** Related to Where Mountains Are **Moving**?
    - How is Earthquake **Depth** Related to Where Mountains Are **Growing**?
    - How is Earthquake **Strength (Magnitude)** Related to Where Mountains Are **Growing**?

11. While looking at Seismic Explorer, use your new map to annotate any other patterns we find related to earthquakes and the sizes of the mountains.

With your class

12. Share your data and observations with the class. Work with your class to update the Class Map.

Revisit our cause board.

With your class

13. As a class:

- Let's revisit our cause board to determine if earthquakes cause or are correlated with mountain movement and elevation change.
- Do we have evidence to support earthquakes causing mountain changes?

Consider our data types and next steps.

Turn and talk

14. Turn and talk to a partner about the following questions:

- Where have we collected data from?
- What perspectives did we use to look at that data?
- Are there still some data that we cannot explain, or have questions about?

Consider what is underground.

Turn and talk

Let's think more about how Earth's underground might compare at different locations where earthquakes occur frequently versus where they don't. Let's start by considering the location where we live.

15. Turn and talk to a partner about the following question:

- If you could dig down to see underground, what do you predict you would find:
- A couple inches down
- In the first hundred feet down
- A couple of miles down (1 mile = 5,280 feet)

Home Learning

Home Learning

16. Read an article about Earth's surface.

- Consider what Earth's surface looks like where you live, and describe what it is like near your home or school.
- Record it on your home learning.

Be ready to share your noticings in class!

Lesson 3: How does what we find on and below Earth's surface compare in different places?

Navigation

With your class

1. We have seen evidence that:
   - The material on Earth's surface can crack open when an earthquake happens.
   - Some earthquakes are bigger in magnitude than others.
   - Some earthquakes occur deeper underground than others.

In your notebook

2. During your home learning, you made observations about what you found on the surface around where you live. In your notebook, record your answer to the question:
   - Do you think you would find the same types of earth materials on and below the surface if you were to examine the surface as well as dig down from the top of Mt. Everest?

Develop a predictive model.

In your notebook

3. In your notebook, develop a predictive model of what you think you would find at the top of Mt. Everest:
   - On the surface
   - Below the surface:
   - A couple inches down
   - In the first hundred feet down
   - Thousands of feet down *(1 mile = 5, 280 feet)*

With a partner

4. Share your model with a partner.
   - What similarities do you notice as you share your models?
   - What differences do you observe?
5. Be ready to share with the class.

Gather additional data.

Let's gather additional information that will help us identify what has been found underground at different locations on Earth.

Turn and talk

6. Before we do, turn and talk with a partner:
   - Who might want to dig deep underground?
   - Why do you think people dig deep down underground?

Analyze data from multiple sites.

Writing in Science

7. For each of the sites listed in the data table on the handout your teacher gives you, document:
    - the data source.
    - what you observe about earth materials on the surface and below the surface.
8. Examine the images for the 5 mountain sites from our *Data Cards for Other Mountains and Mt. Everest*.
    - Look for evidence of the materials on and below the surface of Earth.
    - Document information in your data table.

Feel free to use your *Data Cards for Other Mountains and Mt. Everest* from Lesson 1 for additional information about these sites.

9. Your teacher will share a set of *Earth Materials found at the Mountain Sites* with your small group. Use these and the images on the slides to record your observations for each site in your handout.

Sharing Patterns

With your class

10. With your class respond to the questions:
    - How does what we find on the surface at these different sites compare?
    - How does what we find below the surface at these different sites compare?

Revisit our predictive models.

In your notebook

11. Think about the evidence we have collected about materials we find on and below the surface of Earth. In your notebook:
    - Revisit your predictive model.
    - Use a different colored marker or pencil to make changes, if needed, to your model so that it better reflects what you have learned about the materials found on and below the surface of Earth.

Exit Ticket

On your own

All the sites we analyzed showed evidence of solid rock, or bedrock, at some point below the surface.

12. Answer these questions as an exit ticket:

- Do you see any evidence of solid rock, or bedrock, at the surface where you live? If so, describe the evidence.
- Do you think we would find solid rock, or bedrock, below the surface where you live? Why or why not?

Home Learning

Home Learning

We have figured out some things about what it is like deep underground in different areas of the world.

13. Tonight, go home and share what we have been figuring out in class about the surface of Earth and what is underneath the surface. Then poll your family and friends with the following questions:

- What do you know about what it is like underground in our community?
- Have you ever dug far underground in our area and reached solid rock, or bedrock? What is it like? What kind of solid rock or material is it?

Revisit the home learning.

Turn and talk

For home learning, we asked trusted family members and friends about what type of rock might be found underground in our community.

14. Turn and talk with a partner:

- What were some things your trusted family and friends shared in your poll?
- Share what you heard with your partner. If you were able to take a photo or draw an image of the rock in your area, share that too with your partner.

15. Turn and talk with a partner:

- What do we know about the materials on and below the surface at:
  - Mount Everest?
  - Ridgecrest, California?
- What kinds of changes occur at Mount Everest every year?
- What kinds of change occurred at Ridgecrest in 2019?
- How does this information influence our thinking about what it would take to cause these kinds of changes at Mt. Everest and Ridgecrest?

Rock Investigations

With your group

16. With your small group:

- Your group will be given a bin of materials.
- In the bin are three *Rock Investigation Cards* and the supplies you need to conduct the investigations.
- As you work with your group to carry out the investigations, document observations and responses to the questions in your copy of *Rock Investigations Data Cards.*

With your class

17. With your class, debrief the rock investigations:

- What are some things you figured out about the different types of rock found at the mountain sites?
- What happens to rock when it experiences high temperature and pressure deep below the surface of Earth?
- Why might these ideas be important in helping us figure out the changes happening at places like Mt. Everest?

Revisit our predictive models.

In your notebook

18. Revisit your predictive model in your notebook:

- Look back at the predictive model you developed and revised last class.
- Think about what you now know about the materials we would find on and below the surface of Mt. Everest.
- What, if anything, would you revise in your model? Why?

19. Record in your Progress Tracker what you have figured out. Open your notebook to the Progress Tracker section and turn your notebook sideways so you can draw a three-column table like the one on the slide.

- Write the lesson question in the left column:
    - How does what we find on and below Earth's surface compare in different places?
- Use words and pictures to document what you have figured out.
- Remember to include sources of evidence that support your thinking.

Lesson 4: What is happening to Earth's surface and the material below it during an earthquake?

Navigation

Turn and talk

1. Consider the earthquakes near Mt. Everest and Ridgecrest, CA and discuss:

- Based on your previous investigations, what would you expect to be similar about what you would find a couple of miles below the surface at both of these locations?

Developing a Model for One of Our Case Sites

With your class

2. How could developing a model of what happened at and below the surface at Ridgecrest help us figure out what might have happened at Mt. Everest?

Revisiting What the Surface Looked Like BEFORE the Earthquake

With your class

3. Revisit the map of Ridgecrest and identify the different land structures found in the area and develop a profile model of the area noted in the dotted rectangle.

Revisiting Images from Ridgecrest

With your class

4. Revisit images taken of the land at and around Ridgecrest, including the satellite images. Add new ideas to the profile model of Ridgecrest after the earthquake.

Turn and talk

5. Think about how the piece of pink insulation could represent the bedrock across the region shown in the light blue box.

- What do you think happened to the solid bedrock just under the surface across this entire area at the time of the earthquake that could explain why we saw a shift in the surface of the land?

Make predictions.

Scientists Circle

6. Make predictions about how the bedrock is affected:

- How big do you think the entire piece of bedrock is to the west of this fracture in the bedrock (fault line)?
- How big do you think the piece of bedrock is to the east side of this fracture in the bedrock (fault line)?
- What data would we need to determine where else on Earth there might be breaks like this in the bedrock?

Navigation

With your class

7. Discuss:

- Is there agreement on how big each piece of bedrock is on either side of the fracture in the bedrock (fault line) near Ridgecrest?
- How could looking back at our earthquake data help to determine where else there might be long fractures in the bedrock (fault lines) around Ridgecrest?

Gathering Evidence for a Profile Model for Part of the Country

With your class

8. Let's look at 10 years of earthquake data (1980-1990) to identify the following:

- What parts of the United States on this map would have relatively few or no fault lines?
- Where do you think some of the longer fault lines are located on the west side of this map? On the east side of this map?

9. Look at the section outlined in the rectangle on the slide:

- How does the surface of the land compare in the locations shown in the blue box below?
- Where do we think we would find fault lines in this box?

With your group

10. Develop a profile model with your small group of the section outlined in the rectangle on the map that is on the slide. Include in your model:

- the regions we discussed
- the depth of the ocean
- sea level
- use the appropriate scale
- what is on the surface
- what is underneath the surface

With your class

11. Share the profile models developed in your groups.

12. Your teacher will demonstrate how to use a new tool in Seismic Explorer that will allow you to see a cross section view of where earthquakes are found for this section of land.

On your own

13. Use Seismic Explorer to:

- Look for evidence of any long fault lines (hundreds of miles long) across this part of the map.

With your class

14. Continue to add to the profile model as a class the section of land that was in the rectangle on the map.

Update Progress Tracker.

On your own

15. Turn to the Progress Tracker section of your notebook and turn your notebook sideways. Draw a line under the last entry you made from the last lesson. In the left column, write the question, *What is happening to Earth's surface and the material below it during an earthquake?*

- Use words and pictures to document what you have figured out.
- Remember to include sources of evidence that support your thinking.

Where else are plates found?

With a partner

16. With a partner, analyze earthquake data for the last 10 years and for the last 30 years on the handout your teacher passes out.

- How many plates do you estimate there are?

With your class

17. There is some debate between scientists about exactly how many separate plates Earth's bedrock is broken into. Why do you think this is? How many plates do you estimate there are?

Navigation

Turn and talk

18. The United States is part of the same plate on Earth's surface, and the peak of Mt. Mitchell (in the Appalachian Mountains) is moving to the west at 2 cm per year:

- What do you think is happening to the bedrock below it?
- Do you think something similar is happening to the land at the surface many miles to the west and to the east of Mt. Mitchell?

Lesson 5: How does plate movement affect the land around mountains such as Mt. Everest?

Sharing Predictions

The peak of Mt. Mitchell (in the Appalachian Mountains) is moving to the west at 2 cm per year.

Turn and talk

1. What changes the deeper you go below Mt. Mitchell?
2. What do you think is happening to the land at Earth's surface many miles to the west and to the east of Mt. Mitchell?

Analyzing GPS Data

Calculations using GPS data show that the North American Plate moves approximately 2 cm every year.

With your class

3. What evidence is there that the plate is moving?
4. What do you notice about the direction of movement at different locations on the plate?

Examining the Whole North American Plate

With your class

5. As we zoom out to observe the entire North American Plate, what do you notice about plate movement?

Make a prediction.

With a partner

6. Using your handout, predict where you think the North American plate will be located many years into the future?

Use a model to explain.

With your group

7. Using your model for the behavior of bedrock many miles below Earth's surface, explain what is causing the North American Plate to move 2 cm per year. Be prepared to share your ideas with the whole class.

Update plate profile model.

With your class

8. What should we add to our class model of the North American Plate cross section that could help explain what is causing Earth's surface to move?

Make a prediction.

We just came up with an idea to help explain how the North American Plate moves slightly each year.

With your class

9. Do you think other plates move in the same way?
10. What kind of data would we need to support or refute these predictions?

Return to Seismic Explorer.

With your group

11. Investigate what is happening with different plates on Earth's surface.
12. Record things you notice and wonder about in your notebook. Be prepared to share what you notice and wonder about with the whole class.

Putting the Pieces Together

With your class

13. What are some things you notice about the plates on Earth's surface?
14. How do they compare to the area around North America?
15. What might be causing this movement?

Exit Ticket

On your own

16. What new questions do you now have?
17. By looking at plate movement near Mt. Everest and other mountains, how can we explain what is happening to them?

Lesson 6: How could plate movement help us explain how Mt. Everest and other locations are changing in elevation?

Navigation

With your class

1. What have we figured out in this unit that might help us explain what caused our mountains to change?
2. How can we gather evidence to figure out whether plate movement causes mountains to change?

Identify necessary model components.

With a partner

3. Turn and talk with a partner:
    - What parts will we need to have in our models?
    - How are those parts arranged?
    - How do those parts affect each other?

With your class

4. Make a list of what to include in our models.

Prepare for modeling.

With your group

5. Get together with your group:
    - Listen to your teacher's directions.
    - Get your materials and your handout.
    - Record your group's plate rock types and movement types on the handout.
    - Make sure you know your role in the group.
    - Make predictions about what you think you might see happening as you move the plates.

With your class

6. Share your ideas with the class.

Physical Modeling

With your group

7. Develop a model of plate interactions:
   - Get water for the bottom layer of your model.
   - Float the plates on top of the liquid layer.
   - Move the plates by holding them at the back.
   - Repeat each of the 3 types of movement multiple times.
   - Carefully record your observations in each section of your handout.
8. Clean up your lab materials.
9. Begin to plan the different models you'll create in the next class period.

Create diagrammatic models.

With your group

10. Review your observations about how your physical models moved.
11. Plan and create a model to show each type of plate movement that you observed.
    - Include all the parts and interactions you saw.
    - Include details that help explain what your model is showing.
    - Give your model a title and make labels or a key.
    - Display your models for others to see in the gallery walk.

Gallery Walk

With your class

12. Listen to your teacher's instructions about identifying models that are mostly the same.

On your own

13. Get some sticky notes and a pen:
    - Circulate around the room to the different areas to compare models.
    - For each area, record on a sticky note which models are mostly the same.
    - Post your sticky note in that area.

Create class model chart.

With your class

14. Work with your teacher to create a class chart of all the different types of models showing Different Plate Interactions.

Explain Mt. Everest.

On your own

15. We know a lot about Mt. Everest and how it changes. Can we use one of our models to help explain what is causing Mt. Everest to change?

16. Which of the class models from the Different Plate Interactions chart do you think best explains what we know about Mt. Everest and how it changes?

- Open your science notebook to a fresh page.
- Write which model you chose and why you think it is best.

With a partner

17. Turn and talk to share your ideas with a partner.

18. Decide together which model you both think is best.

With your class

19. Come to a consensus about which model is best.

20. Make a list of why that model is the best.

21. Agree as a class on a claim.

In your notebook

22. Write the class claim on a fresh page in your science notebook.

23. Write a few sentences using evidence to explain why this model best represents what is happening at Mt. Everest.

Explain earthquakes.

With your class

24. Could our models help us explain what causes earthquakes?

With a partner

25. What types of plate movement might show this kind of sudden movement?

With your class

26. As a class, demonstrate what plate motion could be related to earthquakes.

27. Agree as a class on a claim about what causes earthquakes.

In your notebook

28. Write the class claim on a fresh page in your science notebook.

29. Write a few sentences using evidence to explain what causes earthquakes.

Revisit the Driving Question Board.

With your class

30. Look through the questions on the DQB and place sticky dots on those that you think we can now answer.

31. Under what categories did we find questions that we can now answer?

32. Celebrate how much you've figured out together in this unit so far!

Navigation

With your class

33. We've observed and described lots of models of plate movement:

- What else could the plate movement models we developed help explain?
- Besides earthquakes, what other changes on Earth might be caused by plates moving?

Lesson 7: What happens at mountains where we see volcanic activity?

Navigation

Turn and talk

1. With your partner, review the *Possible Causes for Mountain Movement* chart.
2. Discuss the following:
   - What do we know about what causes mountains, like Mt. Everest, to change?
3. Be prepared to share with the class.

Investigating Other Potential Causes

Turn and talk

4. Based on our chart, we need to investigate volcanoes as another potential cause for the kinds of changes that happen to mountains.
   - What do we know about volcanoes?
   - Where do they occur?

Gathering Data from Maps

With your small group

5. Review the set of map images on *Gathering Data from Maps* with your small group. Use the first map image and the map key to discuss with your small group:
   - What do you notice about where volcanoes are located?
6. Use the second map image and its map key to discuss with your small group:
   - What do you notice about where volcanoes are located compared to where earthquakes are located?

Documenting Relevant Data

Writing in Science

7. For each of the sites listed in the data table on the handout your teacher gives you, use the information on the first two maps to document:
   - Whether or not volcanic activity and earthquakes occur nearby.
   - The types of changes that occur on each mountain.

Looking for Patterns in Data

With your small group

8. Use the data you have documented in your data table to discuss:
   - What do you notice about the location of our mountain ranges as compared to where volcanoes are located?
   - What does this tell us about the changes that occur at Mt. Everest and at our other mountain sites?
   - What other data do you think we need to help us figure out whether or not volcanoes cause mountains to move and change in height?

Class Data and Conclusions

With your class

9. Share your data with the class.
10. As the teacher documents data in the class data chart, document your conclusions for Mt. Everest, Mt. Mitchell, and Mt. Narodnaya on your copy of the data chart on the handout:
    - Are the changes to the mountain caused by volcanoes?

Gathering Additional Data

With your small group

11. The third map in the set of map images on *Gathering Data from Maps* shows the plate boundaries and the direction that the plates move. Use the map to discuss with your small group:
    - What do you notice about how the plates move and interact?
    - Which mountain sites are located on or very near to plate boundaries?
12. The fourth map in the set of map images shows where volcanoes occur in relation to plate boundaries. Use the map to discuss:
    - What do you notice about how the plates move and interact at places where volcanoes occur?

Determining Next Steps

With your class

13. Think about what we have learned in the previous lesson and be prepared to discuss these additional questions:
    - What do we already know about how oceanic plates interact with continental plates?
    - How can we check our thinking about the results of the interaction between an oceanic plate moving toward a continental plate?

Oceanic and Continental Plate Interactions

We are now wondering if what we know about plate interactions can help us better understand the interaction between an oceanic plate and a continental plate, and if this might also help us figure out why volcanoes are found where this type of plate boundary interaction occurs.

Writing in Science

14. As you watch the video of the model of an oceanic plate interacting with a continental plate, document what you notice and what you wonder in your science notebook.

Building Understanding

With your small group

15. With your small group, examine the diagram on the slide, then discuss:

- What happens as an oceanic plate and a continental plate collide…
  - In the video of the model from Lesson 6?
  - In the diagram on the slide?
- What other questions do you have now?

Gather information from a reading.

On your own

16. Your teacher will pass out a copy of *How Are Volcanoes Formed and What Kinds of Changes Do They Cause?*

17. Use the close reading protocol as you read.

- Identify the question(s) you are trying to answer with the reading.
- Read once for understanding to see what the reading is about.
- Read a second time to highlight a few key ideas that help answer the question(s) you had.

With a partner

18. Work with your partner to summarize key ideas from the reading.

- Summarize the key ideas(s) in your own words, in diagrams, or both.
- Jot down new questions that this raises for you.

Words We Encounter

With the class

19. Discuss with the class:

- What words or science terms did you come across in the reading that were unfamiliar to you?

Sharing Key Ideas

With the class

20. Share key ideas from the reading that will help us answer these two questions:

- Why are volcanoes found where an oceanic plate collides with a continental plate?
- Can volcanoes cause the kinds of changes we see at the remaining 3 mountain sites in our chart--Mt. Aoraki, Mt. Aconcagua, and Mt. Hotaki?

Putting Ideas Together

With your small group

21. Use the *Data Cards for Other Mountains and Mt. Everest* from Lesson 1 and discuss with your small group:

- Are any of the 3 remaining mountains--Mt. Aoraki, Mt. Aconcagua, or Mt. Hotaki--actually active volcanoes?
- Can a volcano increase the size of surrounding mountains? Why or why not?
- Can a volcano cause a mountain to move? Why or why not?

22. Revisit the class data chart and look at the data we have recorded for the remaining 3 mountain sites--Mount Aoraki, Mount Aconcagua, and Mt. Hotaki. Use the information to discuss the following with your small group:

- Do volcanoes cause the changes in location and elevation that occur at these three sites?

23. Be prepared to share a claim with supporting evidence.

Summarizing what we have figured out.

Turn and talk

24. Turn and talk with your partner:

- What happens at mountains where we see volcanic activity?

Exit Ticket

On your own

25. Oceanic plates in the middle of the ocean move apart from one another. As we modeled this interaction in Lesson 6, we noticed that some of the "mantle" material (water) came up between the two plates.

- What do you think actually happens at the place where two oceanic plates move apart?

26. On your index card, write a claim to explain what you think happens.

Lesson 8: What is occurring at locations where two plates are moving away from each other?

Make a claim about places where plates are separating.

On your own

1. Look back at the claims you recorded about what happens when two oceanic plates move apart.
2. Make sure your claim explains what you think is happening between the two plate edges. You can revise your claim as needed.

Consider locations for evidence collection.

Turn and talk

3. Turn and talk to a partner about the following questions:
   - Do we see any locations where there are plates moving apart?
   - Do any of these locations also appear to have mountains?

Be prepared to share your ideas with the class.

Turn and talk

4. Turn and talk to a partner about the following questions:
   - What type of evidence might we look for to support or refute our claims?
   - Why would we look for evidence that could possibly refute a claim?

Be prepared to share your ideas with the class.

Collect evidence to support or refute claims.

With a partner

5. Work with a partner to examine each artifact. Record any evidence to support or refute your claims on your handout.

Revisit your initial claim.

Writing in Science

6. Look back at your initial claim and determine if the evidence supports or refutes your claim. Complete the last question on your handout.

Sharing Claims and Evidence

With a partner

7. Work with your partner to share your claim and your evidence.

- **Partner A** will share their claim and their evidence supporting or refuting their claim.
- **Partner B** will listen and give feedback to **Partner A** about:
    - Whether their evidence supports or refutes the claim.
    - What evidence could also be used by Partner A to help make their argument stronger.
    - After Partner A has shared, **Partner A and Partner B will change roles.** Partner B will share their claims and Partner A will give feedback.

Revisiting Our Potential Cause Board

Turn and talk

8. Turn and talk to a partner about the following questions:

- Do we see evidence of volcanoes or magma or lava flows causing changes to elevation and location of mountains for all of our mountain cases from our cards?
- Does this help us explain any, all, or none of our mountain cases?
    - If so, how are they causing these changes?
- What do we see the volcanoes or magma doing to the areas where they are located?

Be ready to share your ideas with the class.

Considering Magma Movement

Turn and talk

9. Turn and talk to a partner about the following question:

- What could be causing magma to push out of the surface of Earth?

Be ready to share your ideas with the class.

Update Progress Tracker.

In your notebook

10. Open up to the next available space in your Progress Tracker. Update your Progress Tracker and sources of evidence on your own to answer the following question:

- What is occurring at locations where two plates are moving away from each other?

Lesson 9: What causes mountains to change?

Navigation

On your own

1. Look back at the mountain data cards to remind yourself of the changes happening at the different sites.

With a partner

2. Talk with a partner about:
   - Which of the changes that are happening for our different mountain cases can you explain using what you have figured out so far about what is happening at and below Earth's surface?

Update our potential causes for mountain movement.

With your class

3. With your class, revisit the Potential Causes for Mountain Movement chart and work together to revise it into a Causal Chain of Events poster.
   - Think about all the causes that are on our chart and whether each cause leads to a mountain change or if there are other things that need to happen first.
   - Be ready to share what you have figured out about the different causes we have investigated over the course of the unit.

In your notebook

4. On the next blank page in your notebook, record the question on the slide at the top of the page, "What causes a mountain to change in height or location?"
5. Then explain your answer by stating a claim and explaining your claim.

Revisit DQB.

Scientists Circle

6. In a Scientists Circle, you will receive a sticky note from the DQB from your teacher.
7. Read the question on the sticky note you receive, and think about whether you can answer it using evidence that has been collected over the course of the unit so far.
8. Be ready to share your question and your answer, or that you don't have enough evidence to answer it yet.
9. After you have shared your question, place it either back on the DQB if we can't answer it yet, or on the poster titled, "Questions We Can Answer."

Make predictions.

On your own

10. Your teacher will hand out a copy of *Making Predictions* to you.

11. Answer the three questions on this exit ticket and turn it in before the end of class.

Lesson 10: Where were Africa and South America in the past?

Thinking About the Mid-Atlantic Ridge

With your class

1. Discuss the following questions:
   - If the Mid-Atlantic Ridge is spreading apart one inch per year, does that mean that oceanic plate material has always existed in the Atlantic Ocean?
   - Would there be any changes to the two continents on either side of the Mid-Atlantic Ridge?

With a partner

2. Discuss the following questions:
   - Do you think it is possible that the African and South American continents could have been together once?
   - If they were closer together or touching, how might other areas, like the Atlantic Ocean, look?

   Be prepared to share your ideas with the class.

Calculating Plate Movement

With your class

3. Use the average rate of plate motion to determine when the two continents might have been touching. Look at *Calculating Plate Movement* and read *Scientific Data* with your class.

Determining Location of Data

With a partner

4. We identified that we might want to look at data sources like rocks and fossils. Discuss the following question:
   - If we were to look at the African and South American plates for this type of data, where would we find it?

Be ready to share your ideas with the class.

With your class

5. Discuss the following questions:
   - What are some examples of things in the world, or in your experiences, where there are older things under younger things?
   - Think about experiences you have had where you may have had to "dig" through things to find what you are looking for.

6. Look at the trash can.
    - Where would trash from today be?
    - Where would trash from yesterday be?
    - Where would trash from last week be?

Determining Location of Data

With your class

7. Review the types of data on our maps with your class.
    - Evidence of Past Mountains - This card shows similar mountain ranges, hills, valleys, etc. from this time period.
    - Evidence of Past Glaciers - This shows where glaciers were located during this time period.
    - Location of Fossils - This shows specific types of fossils found that are from this time period.
    - Similar Rock and Mineral Types - This shows rocks that are of the same kind and age from this time period.
    - Evidence of Past Coral Reefs - This card shows data from where coral and marine fossils were found in oceans from this time period.
    - Similar Rock Layers and Formations - This shows rock layers from the two continents.

Sharing Patterns

With your group

8. Share any patterns we found in our data for the African and South American continents.
    - Share your data with your group using the talking sticks protocol.
    - As group members are sharing, use your dry erase marker to mark any areas of similarities or differences between your data sets.
    - After everyone has had a chance to share, discuss the similarities and differences as a group.

Exit Ticket

On your own

9. Using *Lesson 10 Exit Ticket* fill in the blank to make a claim about South America and Africa touching or not touching in the distant past. Then:

- Look across the data sources shared in your groups and list any data sources that you can use as evidence to support your claim.
- Explain why that data source helps to support your claim and if more data made you more or less sure.
- Consider the last question. Do you think that other continents could have also been in different places in the distant past?

Lesson 11: Where were the other plates located in the distant past?

Share your thoughts about the other continental plates.

With a partner

1. Think and share your ideas about how to answer these questions:
   - What's been happening to the other continental plates for millions of years?
   - Where were the other plates located millions of years ago?
   - How could we figure out where they were?
   - What evidence would we need to look at to help us?

With your class

2. Share your ideas about how to answer the questions, and listen carefully to others' ideas.
3. Follow your teacher's instructions to divide into groups.

Start to set up your map.

On your own

4. Get a copy of the base map and a baggy containing continental plate pieces with your type of data recorded on them. Your teacher will also pass out some small Earth squish ball globes.
   - Make sure that you have all 7 continental plates.
5. Position the continental plate material over the continents they represent on the Plate Movement base map.

Compare a flat map and a globe.

With a partner

6. Turn and talk with a partner about the question on the slide:
   - Why do continents look different on a flat map versus your Earth squish ball globes?

With your class

7. What happens when you try to make a flat map of a spherical earth?
8. Watch and discuss the video.

On your own

9. Position the Antarctica continental plate piece on your black and white map with arrows.

Develop an initial model.

On your own

10. Follow the instructions on the slide to organize the continental plate pieces into an initial model showing where you think they might have been located millions of years ago.

- Using the arrows on the flat map and on the globe, move all the continental plates back through time and try to see where they would have been in the distant past and whether any of them were together.
- After you have a preliminary prediction of where the continental plates would have been, use the data on the continental plates to adjust your placement in a way that makes sense based on the data you have.

With your group

11. Compare your arrangement of the continental plate pieces with the other members of your group.

12. Come to a consensus about how to arrange the continental plate pieces based on your data.

Identify strengths and weaknesses of your initial model.

In your notebook

13. Create a T-chart in your notebook.

14. Work together with your group to decide which positions of the continents you have the strongest data to support, and which positions you have less, or weaker data to support.

15. Record answers in the T-chart.

Record your group's model.

On your own

16. Follow the instructions on the slide to carefully record your model in your notebook:

- Make an outline of (or trace) the arrangement of the continents from millions of years ago that your group agreed on.
- Be sure you include the outline of each of the continents.
- Label each of the continents.

17. Get ready to join a new group.

Compare your model with other models.

On your own

18. Follow your teacher's instructions to join a new group.

- Arrange your continents the way your first group decided.
- Create a T-chart in your notebook to record similarities and differences.

- *Silently* observe the other models in your new group and compare them with yours.
- Record your observations in your T-chart.

With your group

19. Compare your arrangement of the continental plate pieces with the other members of your group.

20. Come to a consensus with your group about how the continents were positioned millions of years ago, based on ALL the evidence you have and which arrangement has the strongest evidence to support it.

21. At least one person in your group should record your consensus model so you can remember where you agreed that the continental plates were located.

Identify strengths and weaknesses of your Consensus Model.

In your notebook

22. Create a T-chart in your notebook.

23. Work together with your group to decide which positions of the continents you have the strongest data to support, and which positions you have less, or weaker data to support.

24. Record answers in the T-chart.

Begin the assessment.

On your own

25. Get the first page of the assessment from your teacher.

26. Follow the directions on the slide to complete the first page:

- Make an outline (or trace or draw) the arrangement of the continents from millions of years ago that your group agreed on (the consensus model).
- Be sure you include the outline of each of the continents.
- Label each of the continents.
- Add all the data that you think supports the position of the continents by drawing each type of data and labeling it on your map of the continents.

27. Get the second page of the assessment from your teacher.

28. Follow the directions on the slide to complete the rest of the assessment.

Where did those mountains come from?

With your class

29. Participate in a discussion about mountains from millions of years ago.

Lesson 12: Where did mountains that aren't at plate boundaries today, like the Applachians and Urals, come from?

Navigation

Turn and talk

1. With your partner, use the questions to review what we figured out in the last lesson and to determine where we need to go next:
    - What have we figured out about what causes mountains, like Mt. Everest, to change in elevation and location?
    - Which changes have we not figured out?

Comparing Mountain Sites

With your small group

2. With your small group, look over the information about the Appalachians and the Urals on the *Data Cards for Other Mountains and Mt. Everest* from Lesson 1.
    - In what ways are the Appalachians and the Urals different from the other mountain sites that we are studying?
3. Your teacher will document your ideas on a class chart labeled, *What We Know About the Appalachians and the Urals*.

Sharing Our Thinking

With a partner

4. If the Appalachian and the Ural Mountains are much older than the Himalayas...
    - How might you expect these mountain ranges to look many, many years ago compared to how they look today?
    - What similarities might they have had to other mountain ranges, such as the Himalayas and the Andes?

Gathering Data from Maps

In your notebook

5. Title the page "Gathering Data from Maps."
6. Set it up for documenting observations of two kinds of maps:
    - satellite map
    - relief map

On your own

7. What do you notice that might help explain why the two mountain ranges aren't growing?

Turn and talk

8. What do we already know about the relationship between earthquakes and where plates are located?

9. What do you notice that might help explain why the two mountain ranges aren't growing?

Using a Virtual Simulation of Earth

In your notebook

10. Draw a Notice and Wonder chart on the left page in your science notebook and label the page as shown:

Ancient Earth Globe

Present Day to 240 Million Years Ago

What I Notice	What I Wonder

Working Like Scientists

Turn and talk

11. Scientists often validate the work of other scientists by testing their claims, collecting evidence, and drawing very similar or the same conclusions.
    - How is this similar to the models we developed using data sets about rock types, fossils types, and glacier patterns and the virtual simulation?
    - Be prepared to share your thinking with your class.

Observing the Formation of the Appalachians

In your notebook

12. Draw a second Notice and Wonder chart on the right page in your science notebook and label it as shown:

More than 240 Million Years Ago

What I Notice	What I Wonder

Building Understanding - The Appalachians

With your class

13. What changes did you observe in the Appalachians as the simulation went back in time?

14. What did you figure out about the Appalachian Mountains?

Observing the Formation of the Urals

In your notebook

15. Turn to the next page of your notebook and draw another Notice and Wonder chart on the left page and label it as shown:

The Formation of the Urals

What I Notice	What I Wonder

Building Understanding - The Urals

With your class

16. What changes did you observe in the Urals as the simulation went back in time?

17. What did you figure out about the Ural Mountains?

18. How could we compare the formation of the Appalachians and the Urals with Mt. Everest and the Himalayas?

Observing the Formation of the Himalayas

In your notebook

19. Draw another Notice and Wonder chart on the right page in your science notebook and label it as shown:

The Formation of the Himalayas

What I Notice	What I Wonder

Building Understanding - The Himalayas

Scientists Circle

20. What changes did you observe in the Himalayas as the simulation went back in time?

21. What did you figure out about the Himalayan Mountains?

22. How does this compare with the formation of the Appalachian Mountains and the Ural Mountains?

Constructing a Scientific Explanation

Scientists Circle

23. What claim can we make about the formation of the Appalachians and the Urals, and how their formation compares to the formation of the Himalayas?

24. What evidence do we have to support our claim?

25. How does the evidence support our claim?

Navigation

Turn and talk

26. What processes might be at work to cause the Appalachians to decrease in elevation?

27. Do you think these processes might also explain why the Urals aren't increasing or decreasing in elevation?

Lesson 13: What causes mountains to shrink in elevation?

Share your thoughts.

With your class

1. Discuss the following:
   - what we've figured out about what causes mountains to shrink.
   - what we already know about erosion and weathering from earlier grades.

What are erosion rates?

With your class

2. Watch a video of erosion over time.

On your own

3. Read *Erosion Rates* and note your ideas about erosion rate.
4. Share your ideas with your class.

With your class

5. Think about what relationship processes above and just under the surface might have with changes we see on Earth's surface.

Compare erosion rates and uplift rates.

With your class

6. Compare erosion rates at Mt. Mitchell and Mt. Everest.
7. Using *Erosion Rates vs. Uplift Rates*, think about how processes above Earth's surface and below Earth's surface affect how Earth's surface changes.
8. Add information about Mt. Everest and Mt. Mitchell to your handout.

With a partner

9. Consider these questions:
   - What do you notice about the relationship between the rate of uplift and the rate of erosion at Mt. Mitchell and how the mountain is changing?
   - What is the relationship between uplift rates and erosion rates for a mountain that is shrinking in elevation?

What energy drives erosion and uplift?

With your class

10. Share your ideas about what causes erosion and uplift. Is energy involved? Add additional information to your handout.

Add to the causal chain of events.

With your class

11. Share your ideas to help update your class Causal Chain of Events poster.

Make predictions about the future.

On your own

12. Using *Erosion Rates vs. Uplift Rates*, think about how the erosion rates and the uplift rates will affect Mt. Mitchell and Mt. Everest over time.

Lesson 14: How is there an exposed marine fossil on Mt. Everest? And, what other remaining questions from our Driving Question Board can we now answer?

Revisit the Driving Question Board.

With your class

1. Look back at the Driving Question Board to see:
   - what questions we have made progress on, and
   - what questions we can now answer.

With a partner

2. Read the questions on the DQB that are not yet answered.
3. Discuss the questions and their potential answers with your partner.
4. Place a sticky dot next to any question that we have made progress on answering.

With your class

5. Determine:
   - Which questions have we made the most progress on?
   - What have we figured out?

Revisit the related phenomena.

With your class

6. Revisit the list of potential causes on the Related Phenomena cause board and consider:
   - Can any causes from the cause board help us explain any of our related phenomena?
   - Are the causes listed in Lesson 1 accurate, or do they need updating?

With a partner

7. Pick one related phenomena to explain.
   - Create a model that explains the related phenomenon.
   - After that, explain how this is similar or different from the constructive or destructive processes in our mountain cases.

With a partner

8. Do a gallery walk of the other related phenomena explanations with your partner.
   - Find 2 other models of related phenomena, and consider how the processes in those phenomena are similar or different from your related phenomenon.
   - Write on a sticky note how this phenomenon is similar or different compared to your related phenomenon.
   - Leave your sticky note on that related phenomenon.

With your class

9. What patterns did we notice across the different related phenomena or sticky notes?

10. Were there any similarities or differences that stood out to you?

Taking Stock of What We Know to Explain Related Phenomena

We now know what is causing Mt. Everest to move and change, but we can't explain the marine fossil on the top of Mt. Everest. If we were to try to explain how this marine fossil is found on Mt. Everest, we need to support our explanations with evidence.

With a partner

11. Look back through your notebooks and mark any page or data that can be used as evidence to explain how the marine fossil is found at the top of a mountain.

Scientists Circle

12. Share the evidence from our notebooks that can help explain why a marine fossil is found at the top of a mountain.

Assessment

13. Using the supporting evidence, use the assessment to explain how a marine fossil ended up in the Himalayan Mountains and what will happen to that fossil over time.

Revisiting Our Unit Question

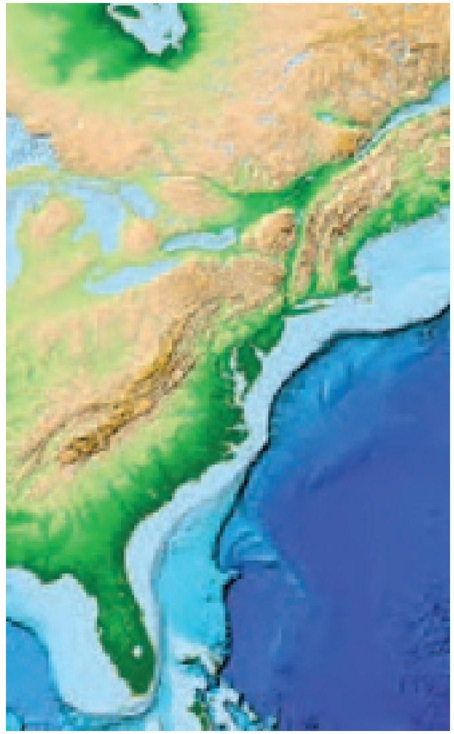
With your class

14. Consider our unit question: What causes Earth's surface to change?

    - In light of what we have learned, what do we think causes Earth's surface to change?

Mountain Case Cards

Mount Mitchell in the Appalachian Mountains



The Appalachian Mountains are a mountain range that covers 1,500 miles in the United States, from Northern Alabama to the Canadian border. The Appalachians are named after the Apalachee tribe. The highest point in this range of mountains is Mt. Mitchell in North Carolina. Mt. Mitchell is 6,684 ft (2,037 m) above sea level. On average, this area is moving about 3 cm per year to the west.

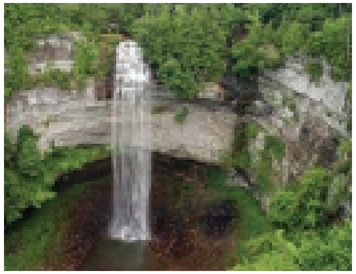
The Appalachian Mountains are ancient, or very old. Scientists believe they used to be as tall or taller than the Himalayas. Today we see evidence that the peaks in the mountain range are decreasing in height. Most of the valleys in between mountains are getting deeper. There are very few active earthquakes happening in this region. The few earthquakes that have happened have been small.

Forests cover most of the mountains in the Appalachian range. A type of sedimentary rock called sandstone is visible along some of the taller parts of the mountains. Some grassy meadows, or flatter areas, also exist on older mountaintops. In some areas of this mountain range, There are waterfalls in some areas of the Appalachians, and rivers twist through valleys in between the mountains.

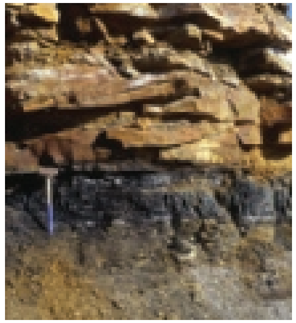
These mountains have all four seasons, and they get a lot of precipitation like rain and snow. that comes from the East coast. Some areas get heavy rainfall in short periods of time, which can sometimes cause flooding.

The Appalachian mountains are mostly made of sandstone. The valleys in between the mountains contain other sedimentary rocks, such as limestone. Volcanic rock can also be found in the mountains. Many prehistoric shells can be found in the rock layers of the mountains.

This is an image of the Great Smoky Mountains, a part of the Appalachian Mountain Range.



Fall Creek Falls in Tennessee



An image showing layers of sandstone above layers of coal in the Appalachian Plateau.

The oldest Trilobite fossil was found in the Appalachians.

Aoraki (or Mount Cook) in the Southern Alps / Kā Tiritiri o te Moana Mountains

This mountain range in New Zealand is about 300 miles long. English settlers gave it the name Southern Alps, but the local Maori people had already named it *Kā Tiritiri o te Moana*. The tallest mountain in this range is called Aoraki (Maori for "Cloud Piercer") or Mount Cook (as named by the English). It is 12,218 feet (3,724 m) above sea level. Aoraki is located on the South Island of New Zealand. This area is moving about 6.9 cm to the North each year.

This mountain range is increasing in height at a rate of 1-2 cm per year. Scientists believe Aoraki should be two and a half times as tall as Mt. Everest based on it being older than the Himalayas. Scientists have data that shows the mountains are also getting broader, or wider. Earthquakes happen regularly off the coast of New Zealand. One recent earthquake caused a part of the seabed to permanently lift above sea level.

The Southern Alps mountains are mostly rocky and covered in ice or snow at the tops. Forests and open grassy areas called meadows, are only found towards the bottom of the mountains. The mountain range contains over 3,000 glaciers, or huge masses of ice, with many lakes located in the valleys between the glaciers. This mountain range gets strong winds and a lot of snow that builds up these glaciers.

These mountains are mostly made of sedimentary rock and volcanic rock layers. Fossils of shells, fish, and other water dinosaurs have been found in and around these mountains.

Image of marine fossils found in the Southern Alps.

Mountains in New Zealand contain many glaciers.

A meadow at the base of a mountain.

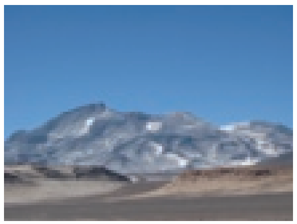
Mt. Aconcagua in the Andes Mountains

The Andes Mountains is the longest continental mountain range in the world. They are located on the western coast of South America and span about 4,500 miles. This is the highest mountain range outside Asia. Most people believe that the mountains were named by the Quechuan people who lived in the Andes in what is now Peru. The highest point is found on Mt. Aconcagua in Argentina at 22,838 ft (6,961 m). This area is moving about 3 cm per year towards the North. The world's tallest active volcano, Nevado Ojos del Salado, is also in the Andes Mountains, in Chilé.

Scientists believe these mountains are about the same age as the Himalayan Mountains. The Andes are still increasing in height, but go through periods of growth spurts. Earthquakes often happen in the Andes.

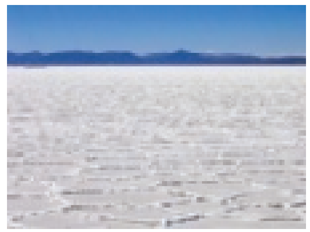
Since the Andes is such a large mountain range, it has many different climates. The Northern part of the Andes are usually rainy and warmer, the middle section is generally more dry, and the Southern section is cooler and gets more precipitation. The height of the Andes causes weather to change quickly. Some rocky snow-covered peaks have rainforests below them. Some mountains in the Andes have glaciers as well. Several large saltwater lakes are found in this mountain range.

The Andes Mountains are mostly made of sedimentary rock, including sandstone and limestone. Volcanic rock is also found inside the mountains. The higher peaks are usually made of a type of rock called granite. There are also very large salt deposits in a section of the mountains called the highlands. Fossils of ancient whales, mammals and reptiles have also been found in these mountains.



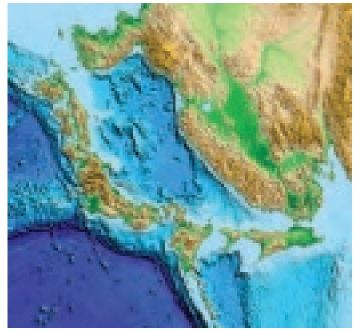
Nevado Ojos del Salado in the summer.

Ammonites were found in the Andes Mountains.



The world's largest salt flat is located in Bolivia in the Andes.

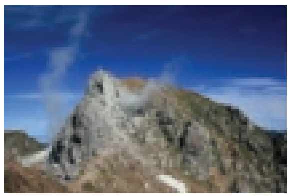
Mount Hotaka in the Hida Mountains



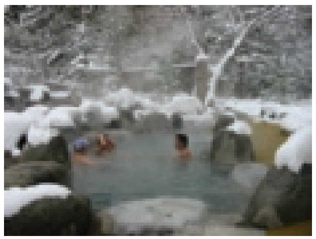
The Hida Mountains or the *Hida Sanmyaku* (飛騨山脈) are in Northern Japan. This mountain range spans 65 miles, and its tallest peak is Mount Hotaka at 10,470 ft (3,190 m). The Hida Mountains were named the Northern Japanese Alps by a British explorer. The Japanese name for these mountains means "Wild Flying Horse." The Hida Mountains are much younger than the Himalayas.

The Hida Mountain range has rocky cliffs and deep narrow valleys called gorges. The Azusa River flows through the mountain valleys and forests, along with other clear streams. Many lakes are also found in these mountains. Meadows between the mountains are known for their flowers and pine trees. This mountain range has several active volcanoes, including Mount Hotaka. In colder weather, people enjoy swimming in the multiple hot springs around the mountain range.

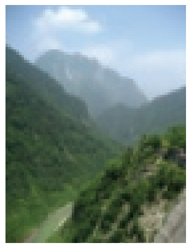
This area of Japan experiences the four seasons. The Hida Mountain Range is known for heavy snow in the winters, and the snow on some mountain peaks only melts in late summer. Heavy rainfall causes flooding in these mountains. The Hida mountains are mainly made up of a type of rock called granite as well as other types of volcanic related rock. The Eastern side of the Hida mountain range bordering the Pacific Ocean also has sandstone, a type of sedimentary rock.



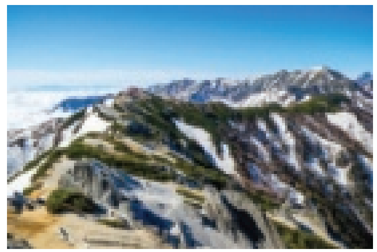
Volcanic gases steaming out of a peak in the Hida Mountains



Visitors enjoying the hot springs in the winter.



The Kurobe Gorge in the Hida Mountains



The Hida Mountains

Mount Narodnaya in the Ural Mountains / Stone Belt Mountains

The Ural Mountains extend from the Arctic Circle to the grasslands of the northern border of Kazakhstan. This mountain range separates Europe and Asia. The mountain range is 1,550 miles (2500 km) long. The tallest peak in the whole range of mountains is Mount Narodnaya, (Гора Народная, На'рода-Из, which translates as "People's Mountain" in Russian). It is 6,214 ft (1894 meters) in height from the ground. The people native to the area referred to these mountains as the "Stone Belt" until the 1700's when the Russians took over Siberia and renamed the mountains the Urals.

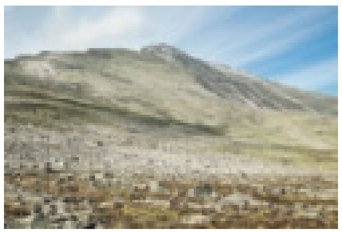
These mountains are about the same age of the Appalachian Mountains.Like the Appalachians, the Ural Mountains are much older than the Himilayan Mountains. Earthquakes can happen in the Ural Mountains, but they are small and not common. This area is moving about 2.5 cm per year towards the East.

Because the range is so long, the Urals are separated into different areas. The Northern Urals are home to glaciers, or huge masses of ice, and are rocky with sharp ridges. The Middle Ural Mountains have shorter flattened tops and lower valleys. The Southern Urals are home to forest animals such as wolves and bears. The Urals have many deep lakes and | rivers that are fed by glaciers in the Northern Ural Mountains.

The Ural Mountain Range is large enough to experience many different climates. There isArctic tundra in the North and forested and semi-desert areas in the South. The Northern Urals experience up to 7 months of winter and cold winds from the Arctic. The Southern part experiences hot, dry air and temperatures over 100 degrees in the summer.

The Ural Mountains are mainly made up of sedimentary rocks such as sandstone and limestone as well as volcanic rock. Marine fossils and other types of fossils have also been found in this mountain range.

A train traveling in a valley in the Urals.



Mount Narodnaya, the highest peak.

Ammonite fossils in the walls of Ural mines.

Sources: https://www.nationalgeographic.com/science/article/australia-moves-gps-coordinates-adjusted-continental-drift#:~:text=All%20of%20the%20E arth's%20continents,with%20a%20slight%20clockwise%20rotation). (Mt Cook)

https://www.unavco.org/software/geodetic-utilities/plate-motion-calculator/plate-motion/model (Mt Cook)

https://earthhow.com/south-american-plate/#:~:text=Plate%20tectonics%20are%20never%20idle,your%20nails%20grow%20each%20year. (Andes)

Ural: https://peakvisor.com/peak/mount-narodnaya.html?yaw=0.00&pitch=0.00&hfov=76.37

https://www.unavco.org/software/geodetic-utilities/plate-motion-calculator/plate-motion/model

Hotaka: https://www.volcanodiscovery.com/japan.html

Himalayas: https://pubs.usgs.gov/gip/dynamic/himalaya.html

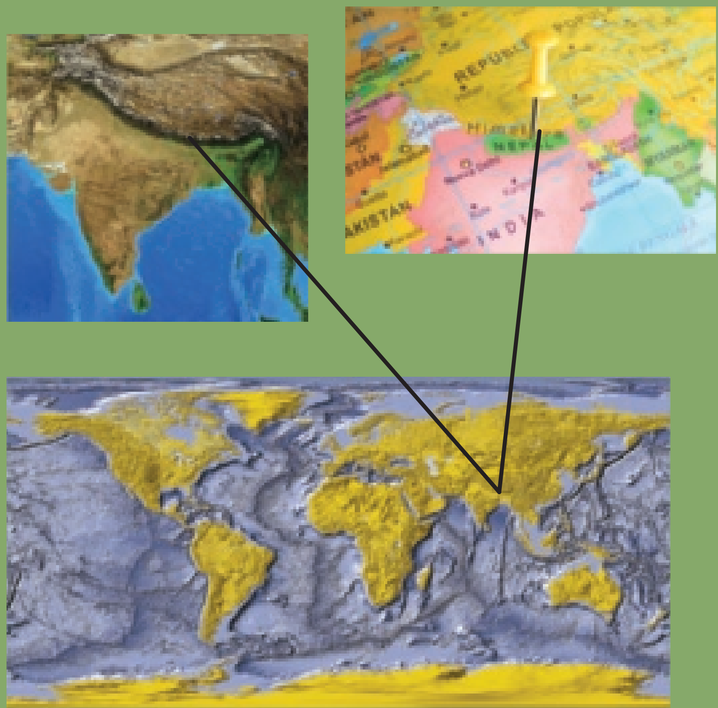
https://sciencing.com/bring-the-outdoors-inside-with-these-nature-kits-for-kids-13763822.html

Data Cards on Other Mountains and Mt. Everest

Mount Everest in the Himalayan Mountains

Height: **29,032 feet above sea level** Movement: **4 cm northeast yearly**

Mt. Everest is located between Nepal and China in a mountain range called the Himalayas. The Himalayan range is 1,500 miles long. In addition to Nepal and China, it also covers parts of the countries of India, Pakistan, Afghanistan, China, Bhutan and Nepal. Not only is Mt. Everest, the tallest mountain in the world located here, but so is K2, the world's second tallest mountain. The area experiences large active earthquakes.

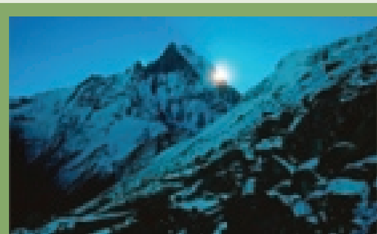


Weather and climate

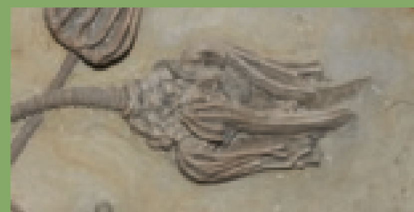
- tropical near the base of the mountains
- snow and ice near the tops of the mountains all year long
- 15,000 glaciers

Earth materials found here

- sedimentary rock such as shale and limestone
- volcanic rock in some areas
- marine fossils on some of the peaks of the mountains

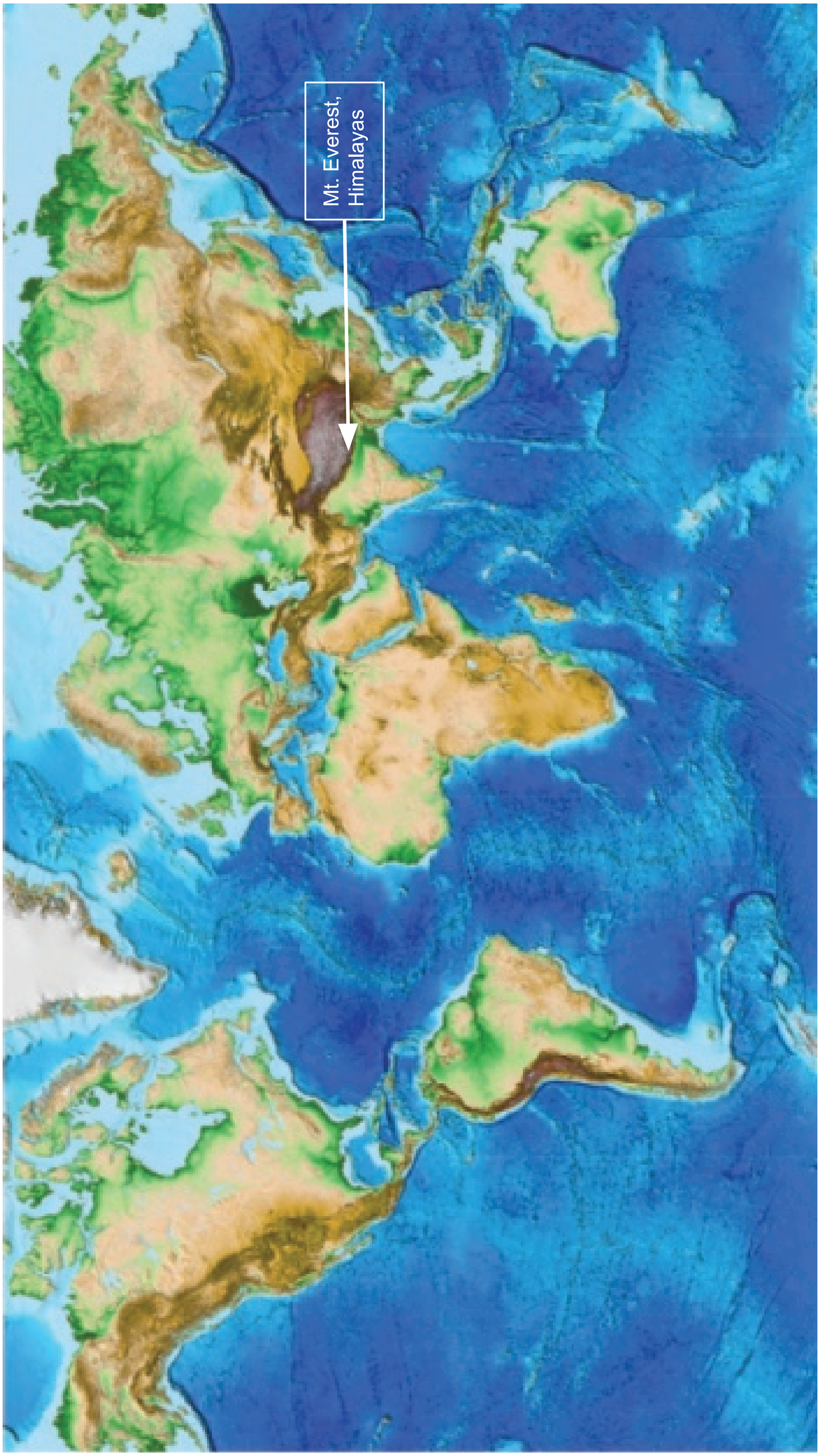


Sunset behind the Himalayas



Many pieces of fossils of crinoids (pictured above), trilobites, brachiopods (lamp shells), and ostracods (small shrimps) are found here.

The name for the Himalayas comes from Sanskrit and translates to "Abode of snow." The Nepalese people named Mt. Everest *Samgarmatha,* which is translated as "Goddess of the Universe" or "Forehead of the Sky." The Tibetan name for Everest is *Chomolungma*, which means "Goddess Mother of the World." These mountains are growing in height, with Mt. Everest growing about 2 cm per year.



NOAA

Mount Mitchell in the Appalachian Mountains

Height: 6,684 ft above sea level **Movement:** 3 cm west yearly

The Appalachian Mountains are a mountain range that covers 1,500 miles in the United States, from Northern Alabama to the Canadian border. The Appalachian Mountains are ancient, or very old. Scientists believe they used to be as tall or taller than the Himalayas.

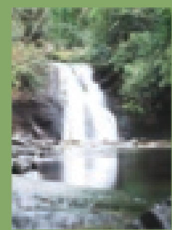
Weather and climate

- Rain and snow is common in this mountain range
- Areas in the north can get snow all year
- Areas in the south have hot dry summers
- Some areas get heavy, fast rains that lead to flooding

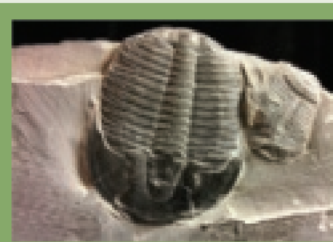
Earth materials found here

- Sedimentary rock such as sandstone and limestone
- Volcanic rock in some areas
- Forests cover most of the mountains
- Grassy meadows and valleys are in between the mountains
- Many prehistoric shells can be found in the rock layers of the mountains

Layers of sandstone above layers of coal



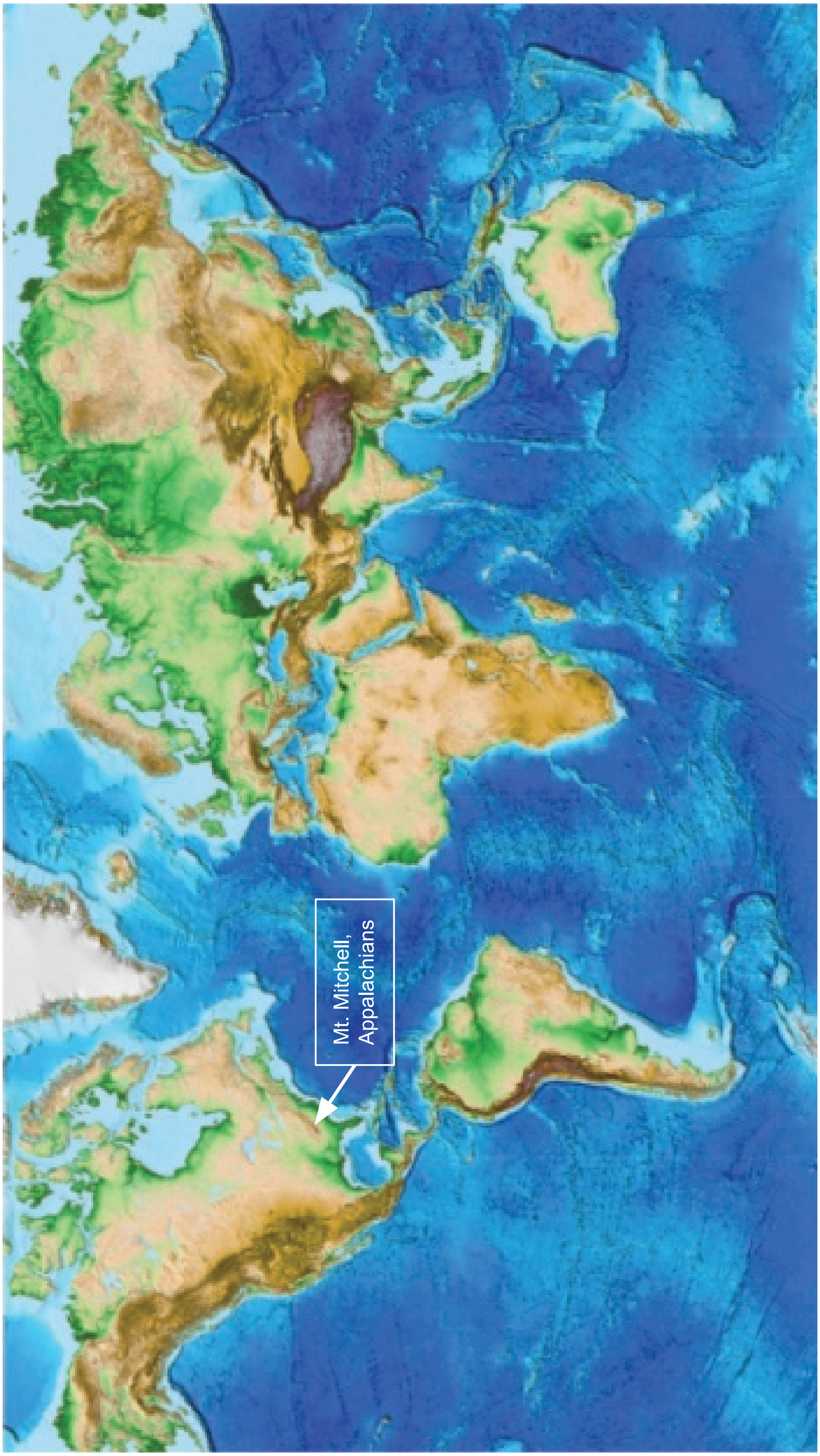
Waterfall found in the Appalachians



The oldest Trilobite fossil was found here

The peaks in the mountain range are decreasing in height. Most of the valleys in between the mountains are getting deeper. There are very few small active earthquakes happening here.

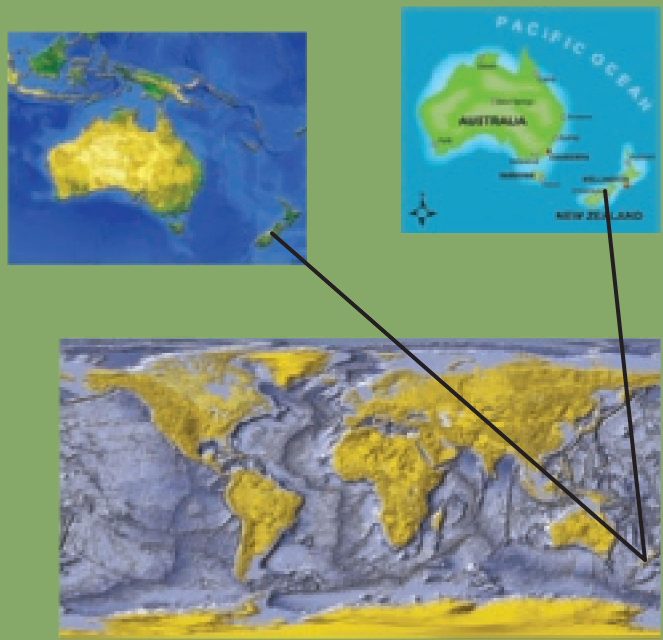
Image credits: Concord Consortium; CIA World Factbook; C.M. Bailey; Yanny Mishchuk; Adolfo Beato



NOAA

Aoraki (or Mount Cook) in the Southern Alps / Kā Tiritiri o te Moana Mountains

This mountain range in New Zealand is about 300 miles long. English settlers gave it the name Southern Alps, but the local Maori people had already named it Kā Tiritiri o te Moana which translates to "the sea is divided". The tallest mountain in this range is called Aoraki (Maori for "Cloud Piercer") or Mount Cook (as named by the English).



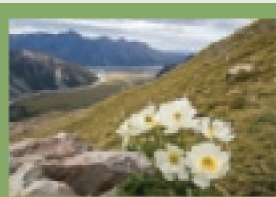
Height: 12,218 ft above sea level **Movement:** 7 cm north yearly

Weather and Climate:

- Strong winds, rain and snow
- Western side of mountains get almost twice as much rain and snow as eastern side
- Over 3,000 glaciers
- Rocky mountains with snow and ice at the top

Earth materials found here:

- Forests and meadows found at the bottom of the mountains
- Sedimentary rock such as sandstone and limestone
- Volcanic rock such as granite
- Fossils of fish, shells and dinosaurs

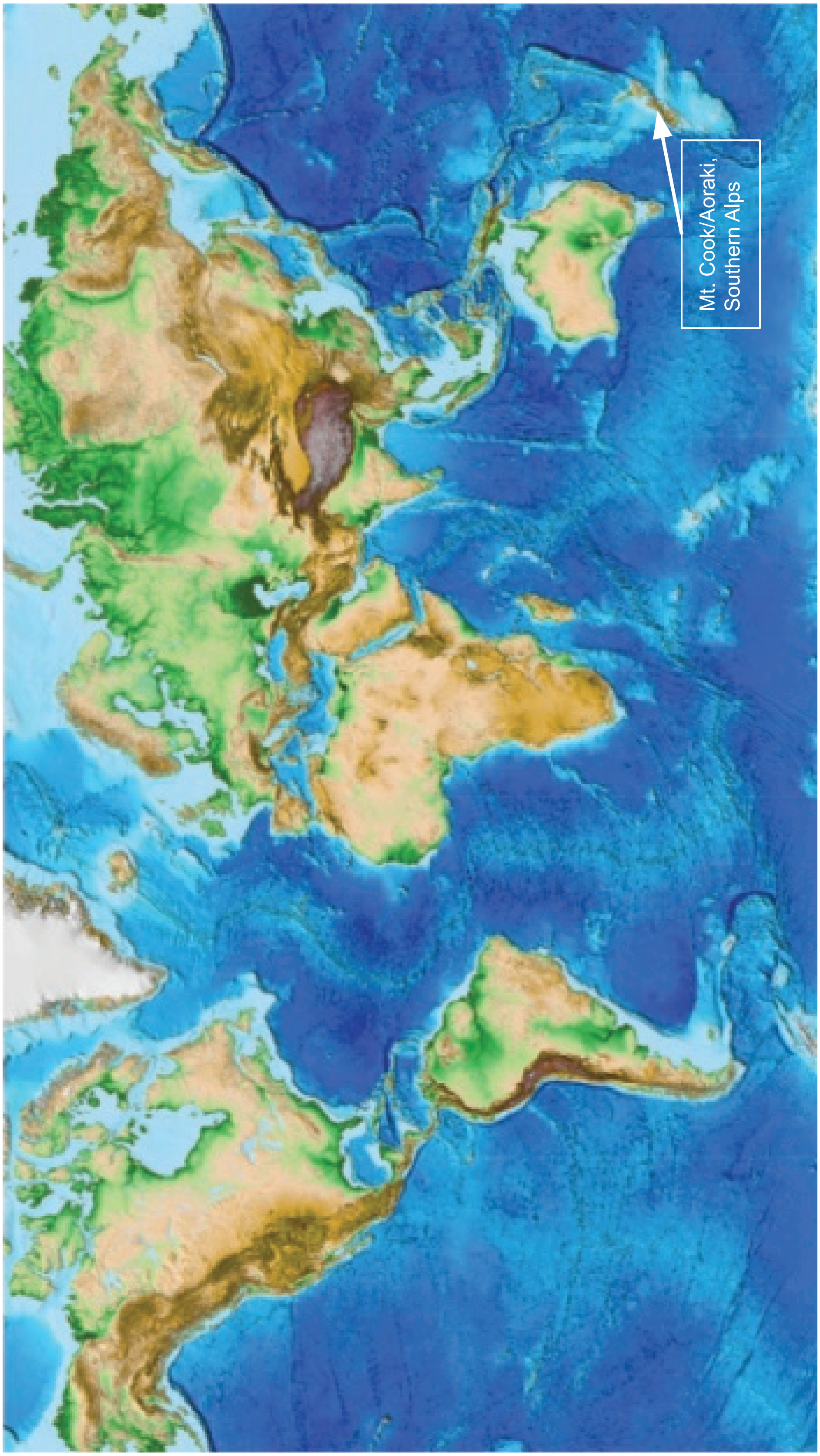


An alpine meadow

Many glaciers can be found in the Southern Alps

Marine fossils are found in the Southern Alps

This mountain range is increasing in height at a rate of 1-2 cm per year. Scientists believe Aoraki, or Mount Cook, should be 2 ½ times as tall as Mt. Everest based on it being older than the Himalayas. Scientists have data that shows the mountains are also getting broader, or wider. Earthquakes happen regularly off the coast of New Zealand. Recently, after an earthquake, part of the bottom of the ocean was pushed up above the water and is now dry land.



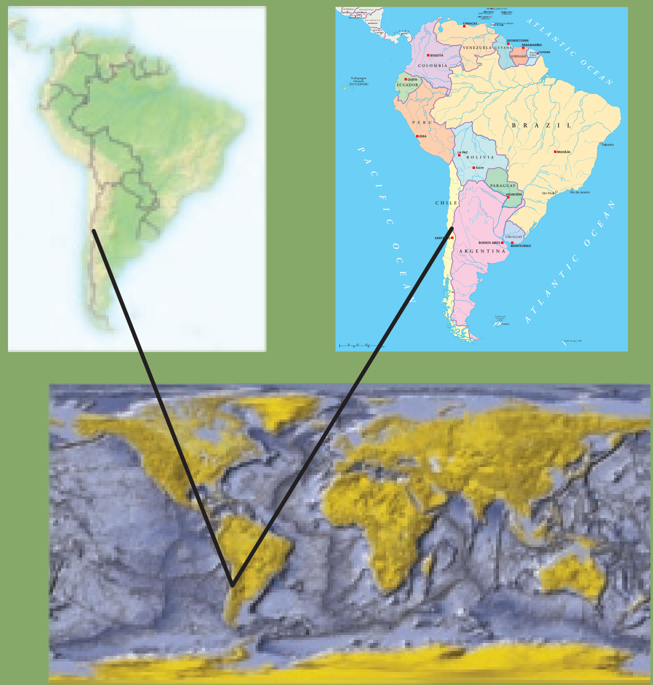
NOAA

Mt. Aconcagua in the Andes Mountains

Height: 22,838 ft above sea level **Movement:** 3 cm north yearly

The Andes Mountains are located on the western coast of South America. They are the longest mountain range in the world at 4,500 miles long. This is the highest mountain range outside Asia where Mt. Everest is found. The world's tallest active volcano, Nevado Ojos del Salado, is found in the Andes Mountains, in Chilé.

This mountain's name has roots in the indigenous Quechua words Anco (white) and Cahuac (sentinel). It is translated as "The Sentinel of Stone."

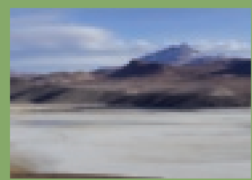


Weather and climate

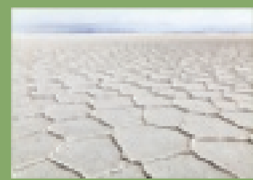
- Many different climates
- North areas are rainy and warmer
- The middle areas are drier
- Southern areas are cooler and get more rain and snow
- Weather changes quickly here since the mountains are so tall
- Glaciers are found in some areas

Earth materials found here

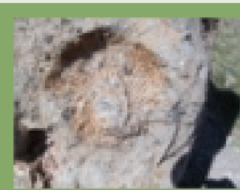
- Sedimentary rock such as sandstone and limestone
- Volcanic rock such as granite
- Salt deposits found in one section
- Rainforests
- Large saltwater lakes
- Fossils of ancient whales, mammals and reptiles.



Nevado Ojos del Salado in the summer.

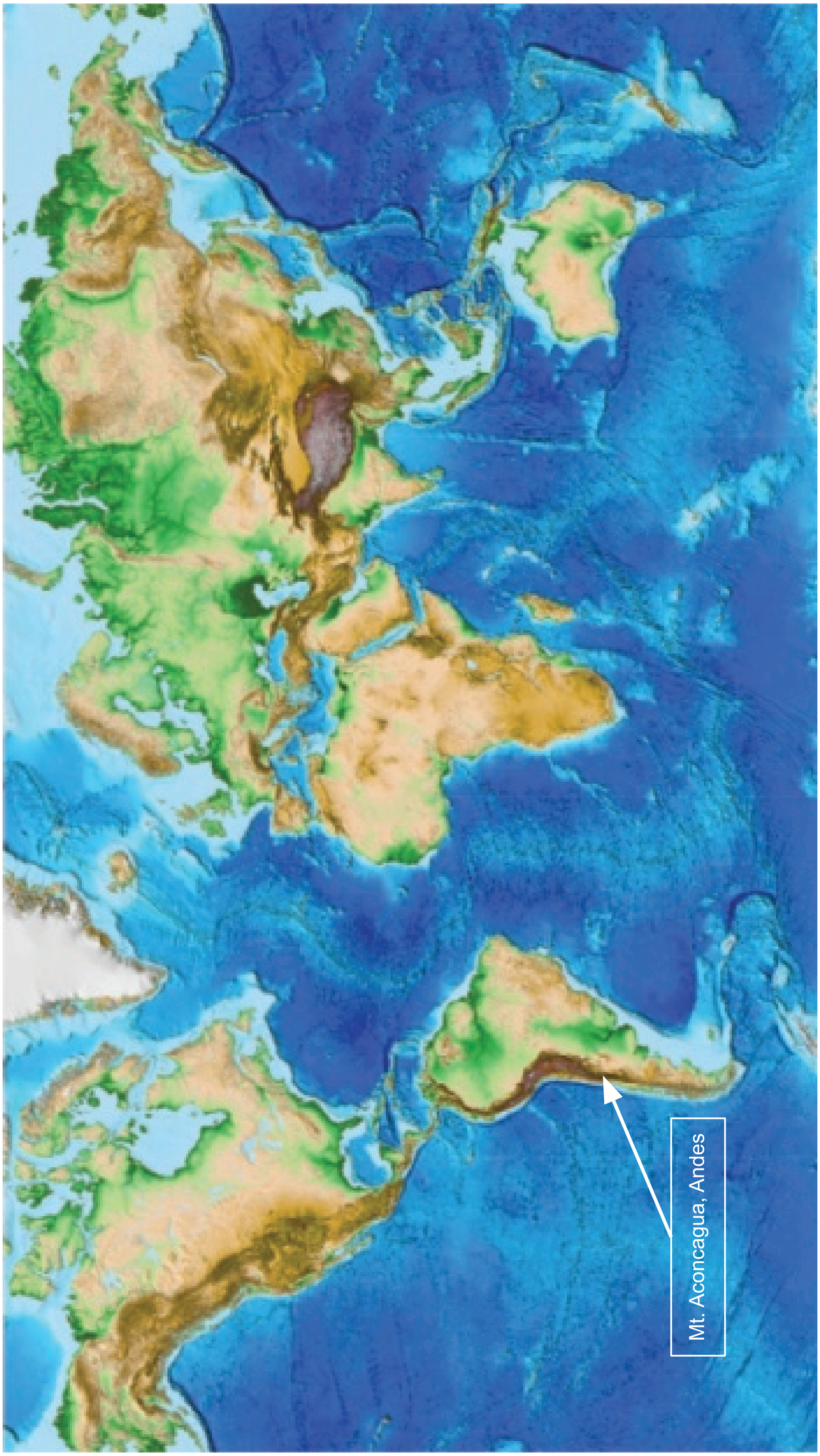


The world's largest salt flat, large ground covered by salts and minerals located in Bolivia.



Ammonites fossils similar to these were found in the Andes Mountains being used as decorations in the side of a building.

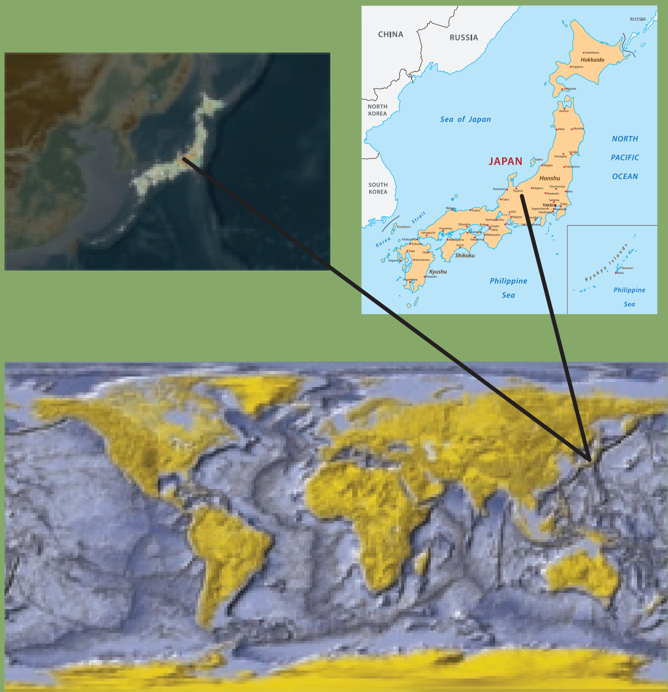
Scientists believe these mountains are about the same age as the Himalayan Mountains. The Andes are still increasing in height, but go through periods of growth spurts. On average these mountains grow about 10 mm over 10 years. Earthquakes often happen in the Andes.



NOAA

Mount Hotaka in the Hida Mountains

Height: 10,470 ft above sea level **Movement:** 1 cm southwest yearly



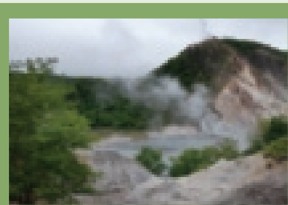
The Hida Mountains or the Hida Sanmyaku (飛騨山脈) are in Northern Japan. The Japanese name for these mountains means "Wild Flying Horse."

Weather and climate

- Winter, spring, summer and fall have different weather conditions
- Heavy snow in winter
- Heavy rainfall in other seasons with flooding

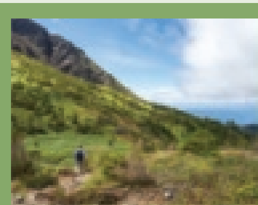
Earth materials found here

- Sedimentary rock such as sandstone
- Volcanic rock such as granite
- Rivers, streams and lakes
- Pine meadows
- Multiple hot springs
- Rocky cliffs and deep, narrow valleys



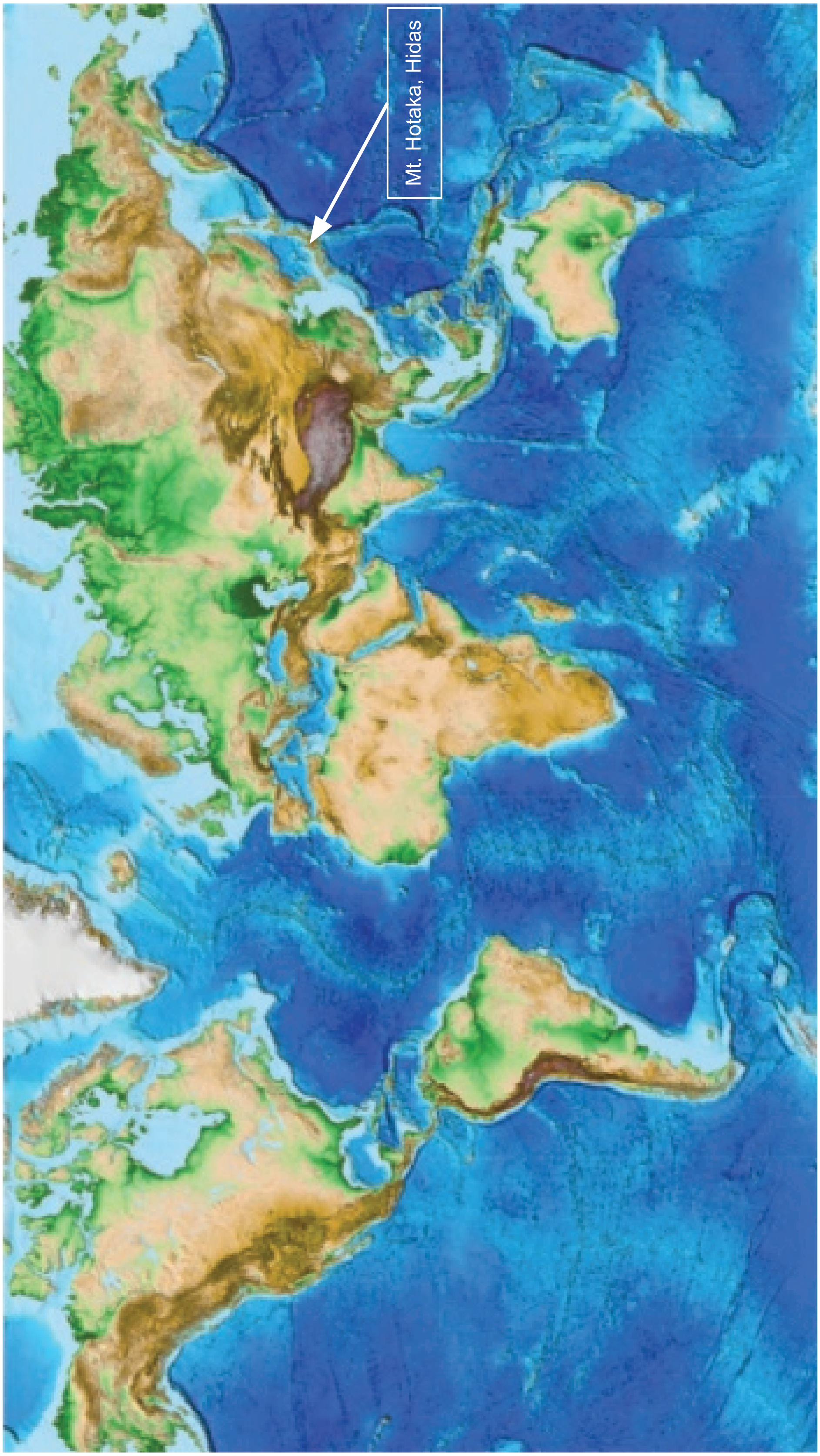
Volcanic gases steaming out of a peak in the Hida Mountains.

Visitors enjoying the hot springs in the winter.



The Hida Mountains

The Hida Mountains are much younger than the Himalayas. There are several active volcanoes in the Hida mountains, including Mt. Hotaka. These mountains are growing by about 4 mm a year. Japan has more earthquakes yearly than almost anywhere else on the Earth.

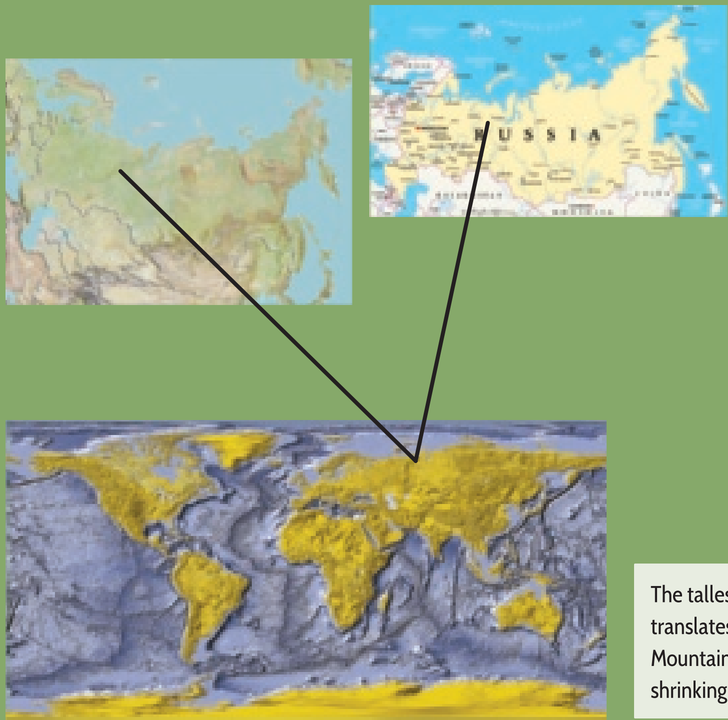


NOAA

Mount Narodnaya in the Ural Mountains

The Ural Mountains extend from the Arctic Circle to the grasslands of the northern border of Kazakhstan. This mountain range separates Europe and Asia. The mountain range is 1,550 miles long.

Height: 6,214 ft above sea level **Movement:** 2.5 cm east yearly



Weather and climate

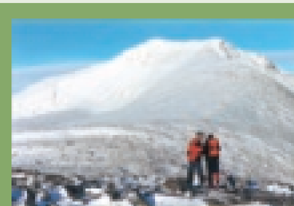
- Many different climates
- Arctic tundra found in the north
- In the north up to 7 months of winter and cold winds
- Forests and semi-desert in south
- In the south, hot and dry air with temps over 100 degrees in summer
- Glaciers in the north

Earth materials found here

- Sedimentary rock such as sandstone and limestone
- Volcanic rock such as granite
- Marine fossils and other types of fossils
- North is rocky, sharp ridges
- South is flat top mountains and deeper valleys
- Deep lakes and rivers

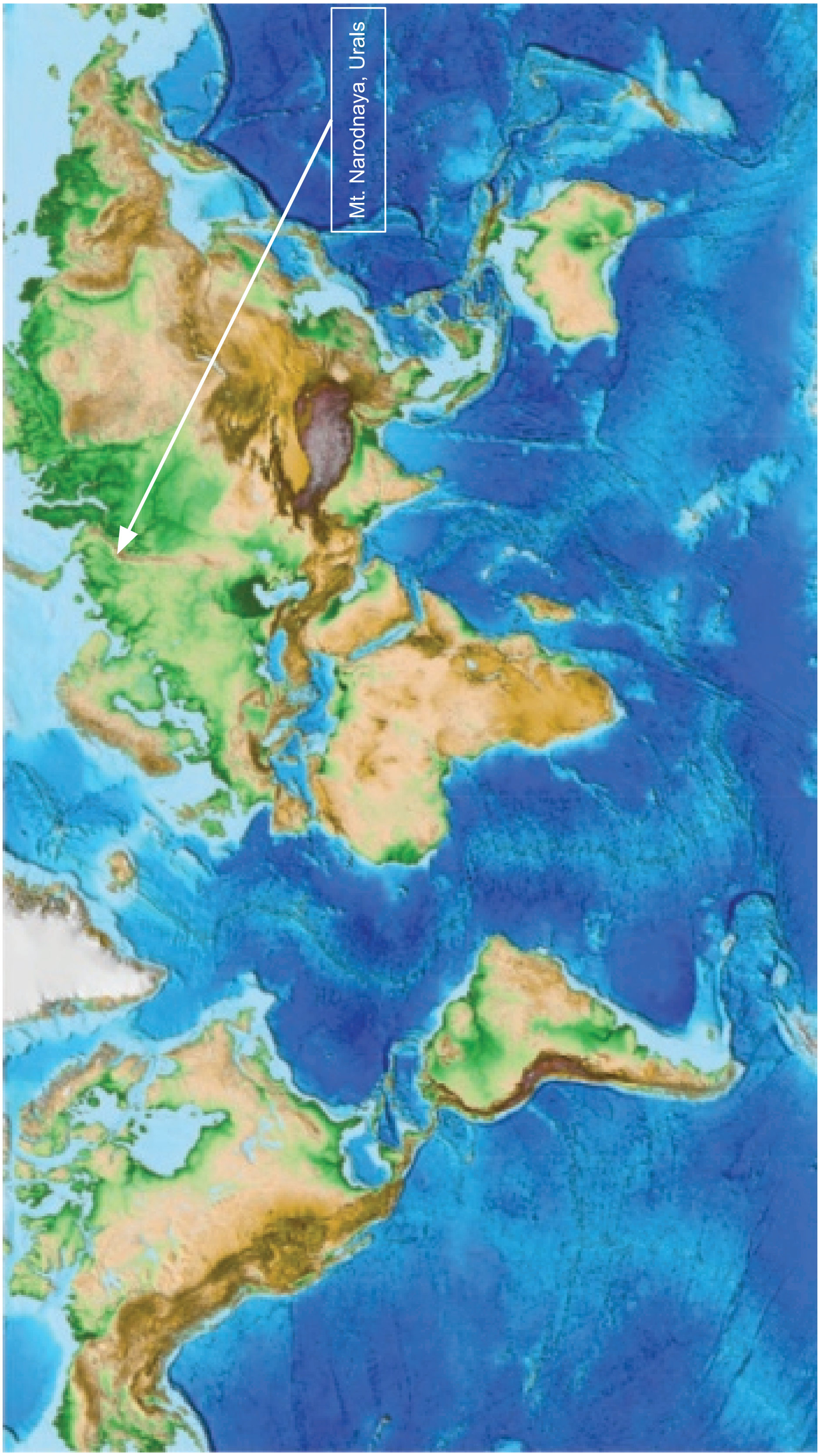
A mountain slope in the Urals.

Ammonite fossils in the walls of Ural mines.



Mount Narodnaya

The tallest peak in the whole range of mountains is Mount Narodnaya, (Гора Народная, На'рода-Из, which translates as "People's Mountain" in Russian). These mountains are about the same age as the Appalachian Mountains. The Ural Mountains are much older than the Himalayan Mountains. The Urals are not growing or shrinking in height. Earthquakes can happen in the Ural Mountains, but they are small and not common.



NOAA

10-Year and 30-Year Earthquake Data

10 years of earthquake data

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30 years of earthquake data

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Gathering Data from Maps

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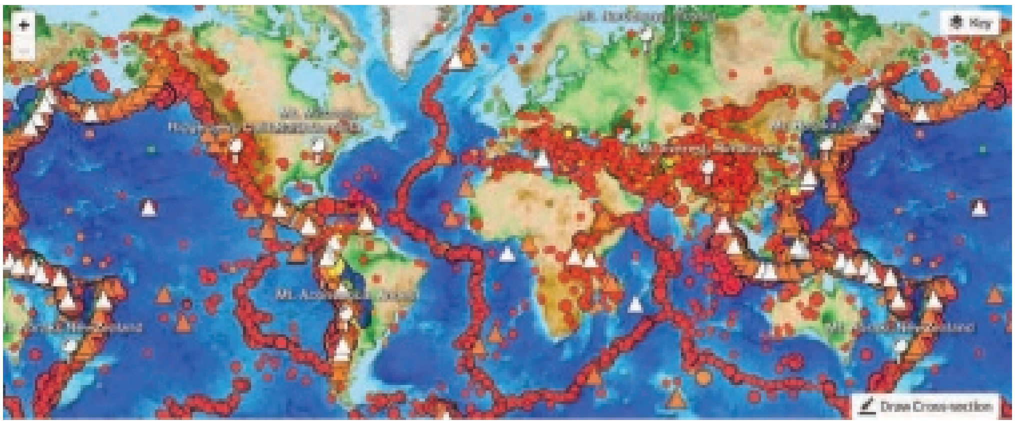

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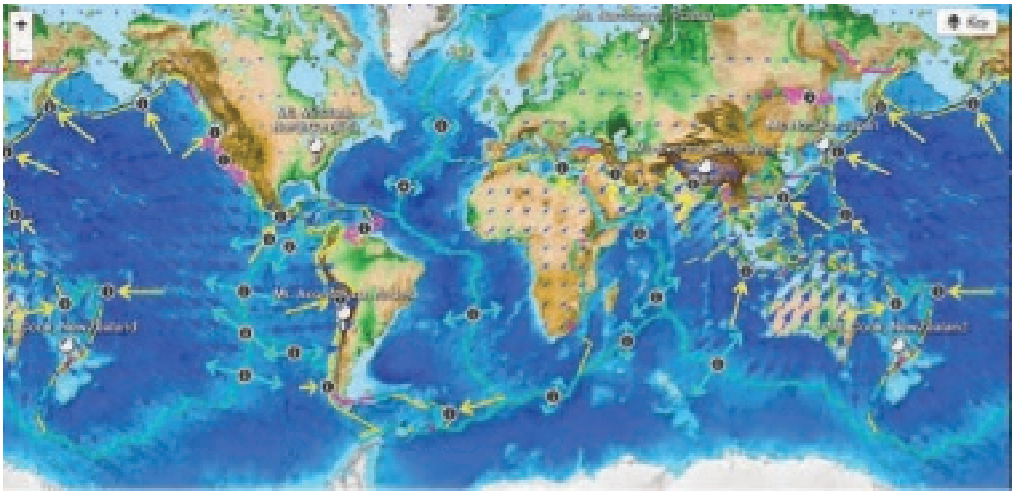
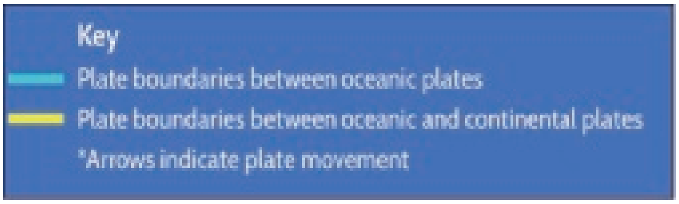
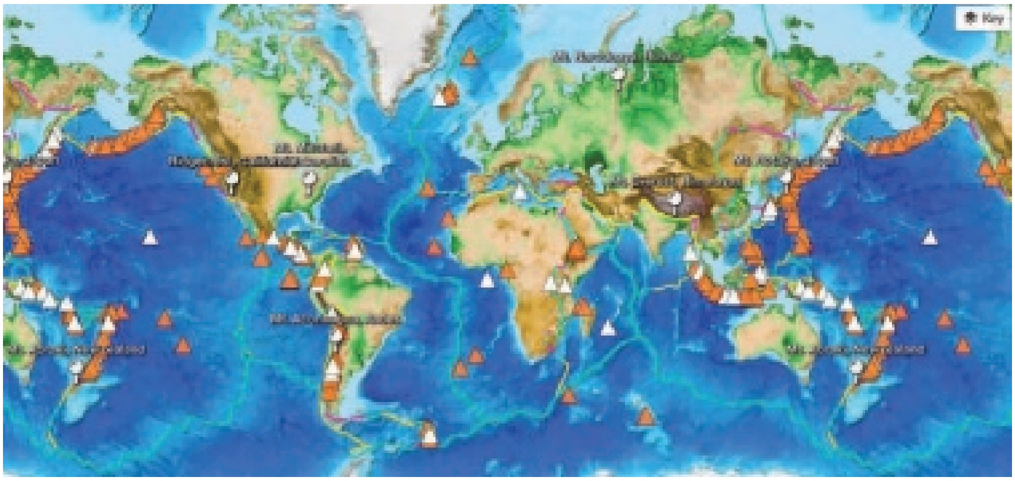
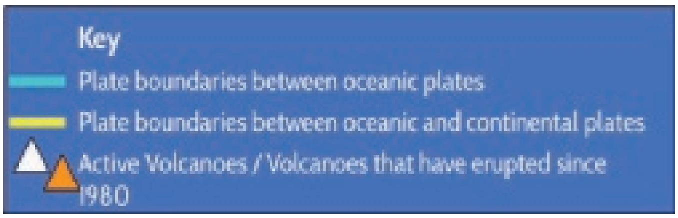



Key
Plate boundaries between oceanic plates
Plate boundaries between oceanic and continental plates
*Arrows indicate plate movement

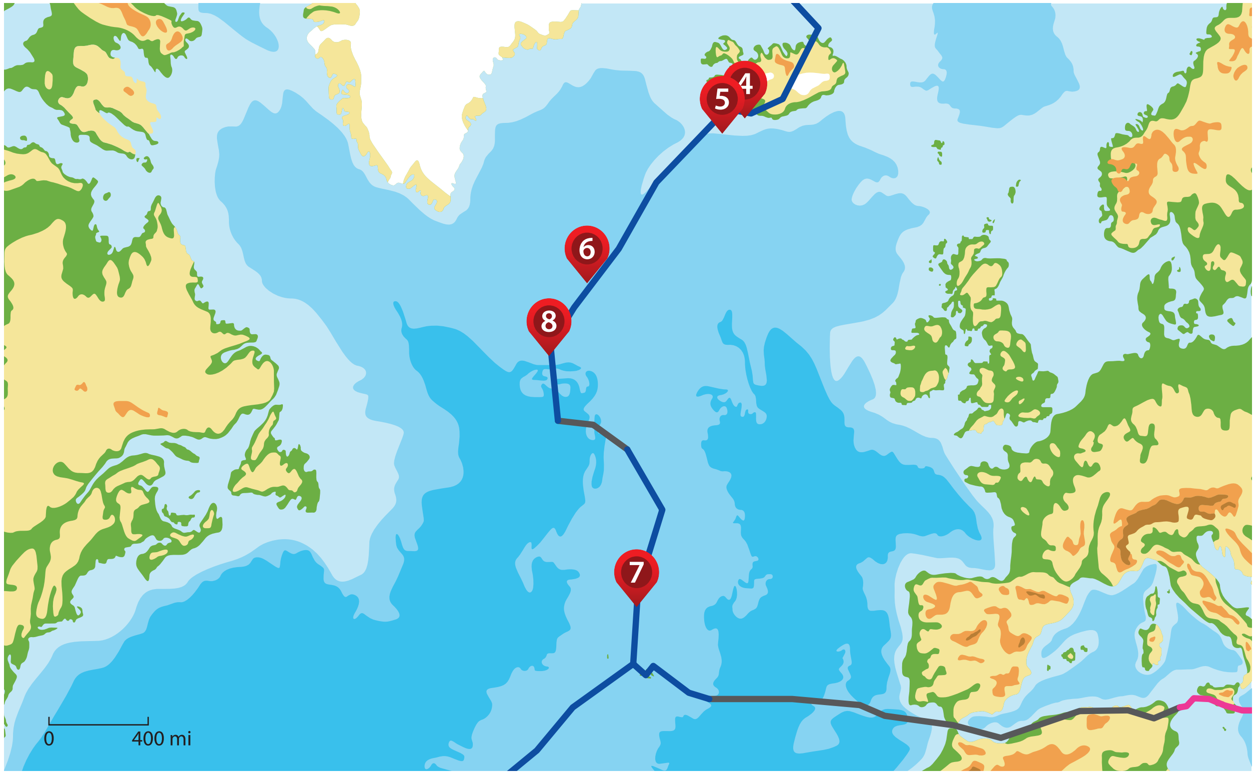



Key
Plate boundaries between oceanic plates
Plate boundaries between oceanic and continental plates
Active Volcanoes / Volcanoes that have erupted since 1980

Mid-Atlantic Ridge Storymap Images

Mid-Atlantic Ridge

Below you will find a map with 7 out of 8 artifacts. Each artifact comes from a point on this map. As you explore your map, keep track of evidence you collect to either support or refute your claim.



Artifact #1

This picture was taken of the Almannagja fissure, located in Thingvellir National Park, Iceland. This picture shows where the two plates are moving apart. What do you notice about this picture? Do you see evidence in the image of where the two plate boundaries are located? How long ago do you think the plates last separated in this area?	

Artifact #2

This diver is swimming swimming in between the two plates that are moving apart.

What do you notice about the plate on either side of the diver? If the plates are moving, why do you think the divers believe it's safe to explore the area?

Artifact #3

This image shows another area of Iceland where the two plates are separating. This dirt-like substance is made of volcanic rock.

Can you identify the edges of the two plates? How could this area be made of volcanic rock, but not have active volcanoes in this location? Why would it look like dirt or sand?

Artifact #4

This picture of the Reykjanes Peninsula shows another area where the two plates are moving away from each other. The ground is made of basalt and is very rocky. In this area there are also very hot gases coming from the ground.

How is this different than artifact #1, and why is it different? What could be happening here that isn't happening in artifact #1?

Artifact #5

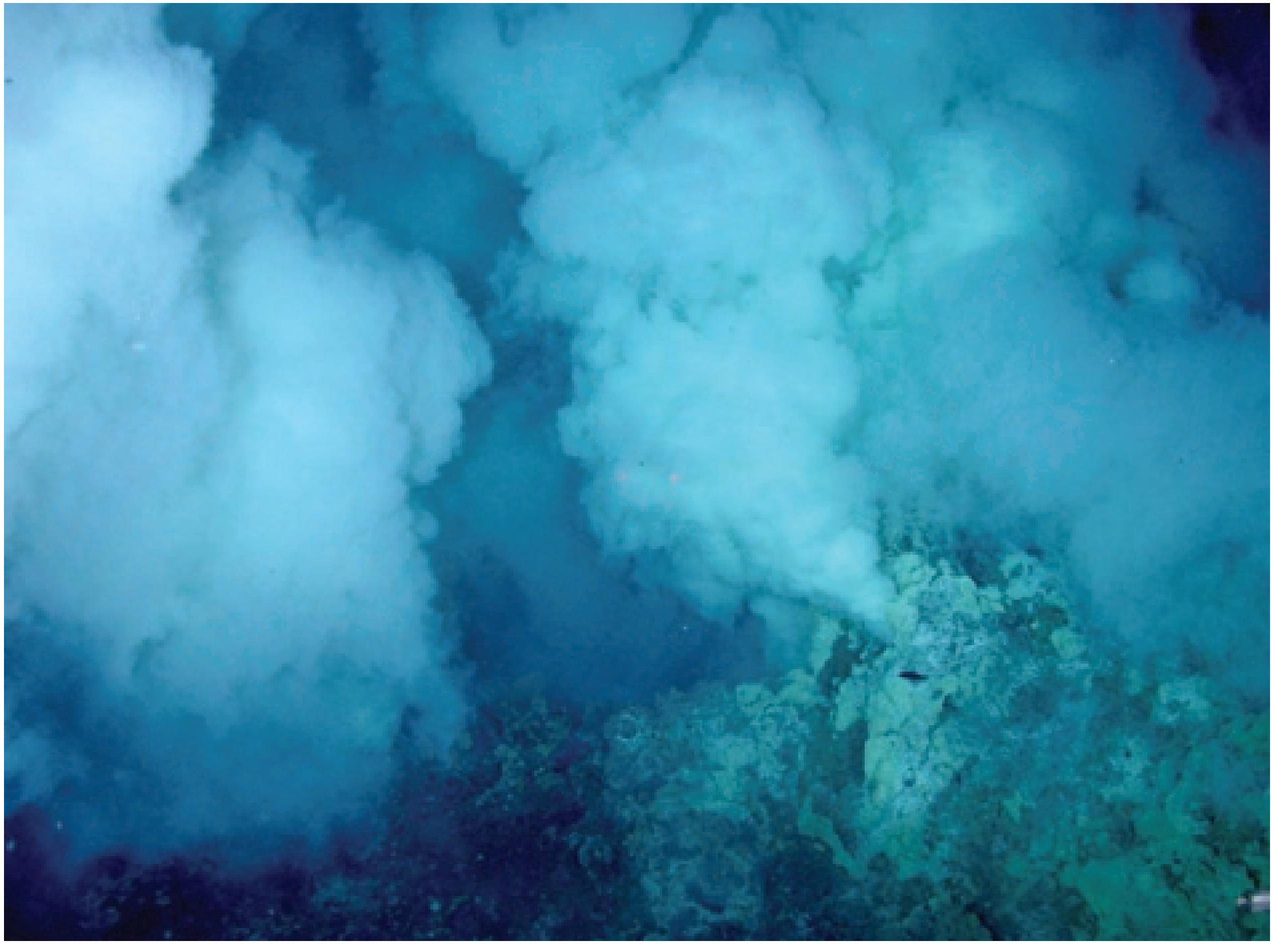
This picture shows another area of Iceland between artifacts 3 and 4. The land had just opened when this picture was taken. This site is not far from a volcanic site, one of the many volcanic sites in the country of Iceland.

What do you see emerging from the cracks in the ground? What does this make you wonder? What is similar in this photo and artifact #4?

Artifact #6

Deep below the ocean on the Mid-Atlantic Ridge, we can find hydrothermal vents. These vents can shoot out some of the hottest water on Earth, at over 400 degrees. Scientists have tried to place instruments in these vents and drill down into them to learn more about their composition, but the equipment begins to melt.

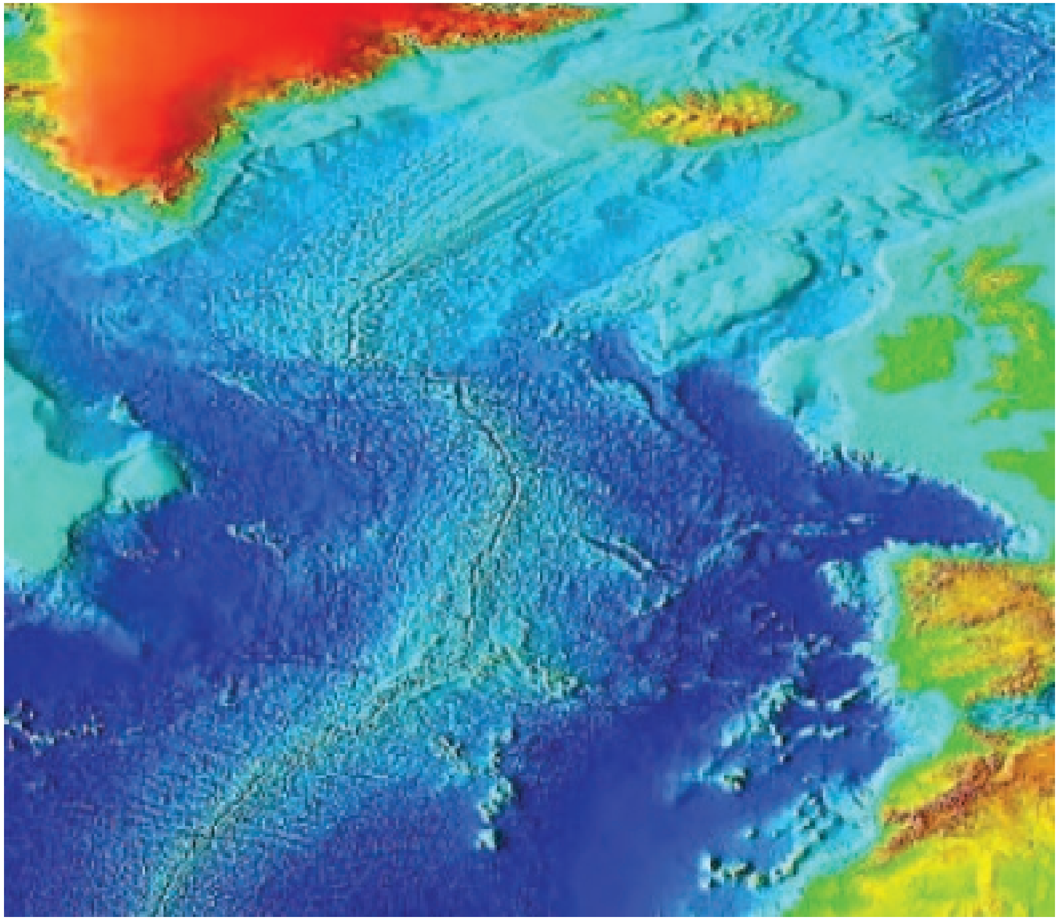
Why do you think the water that has gotten into this vent is so hot? What could be making this water heat up?



Artifact #8

This map is of the Mid-Atlantic Ridge. It was created by scientists and geographers by using elevation data. The colors show how deep or shallow the ocean is, with light blue being closer to the surface of the ocean and dark blue being further from the surface.

What do you notice about the color of the Mid-Atlantic Ridge that follows the center of the map? What can be said about the elevation of the Mid-Atlantic Ridge? What does this chain remind you of?

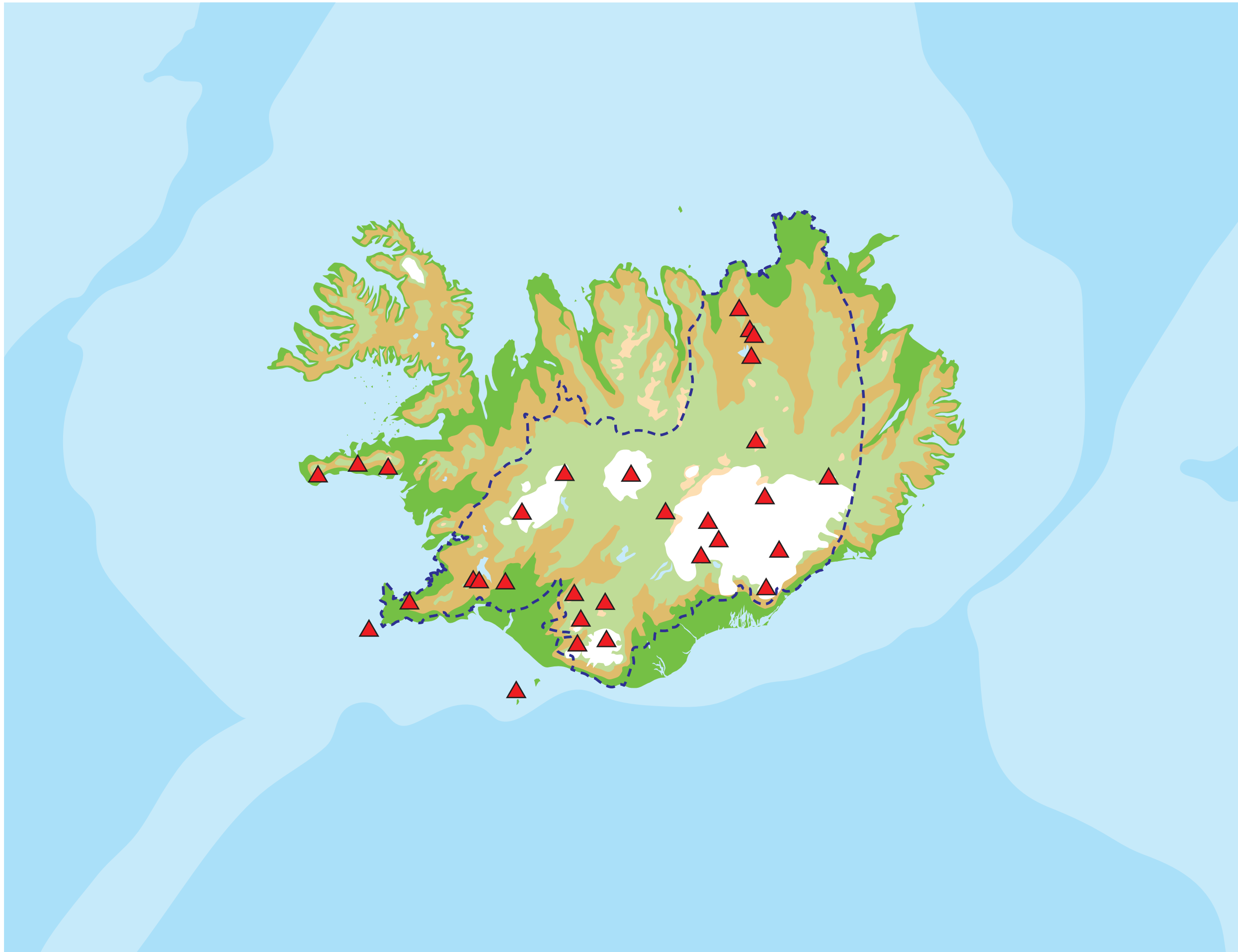


NOAA

Artifact #9

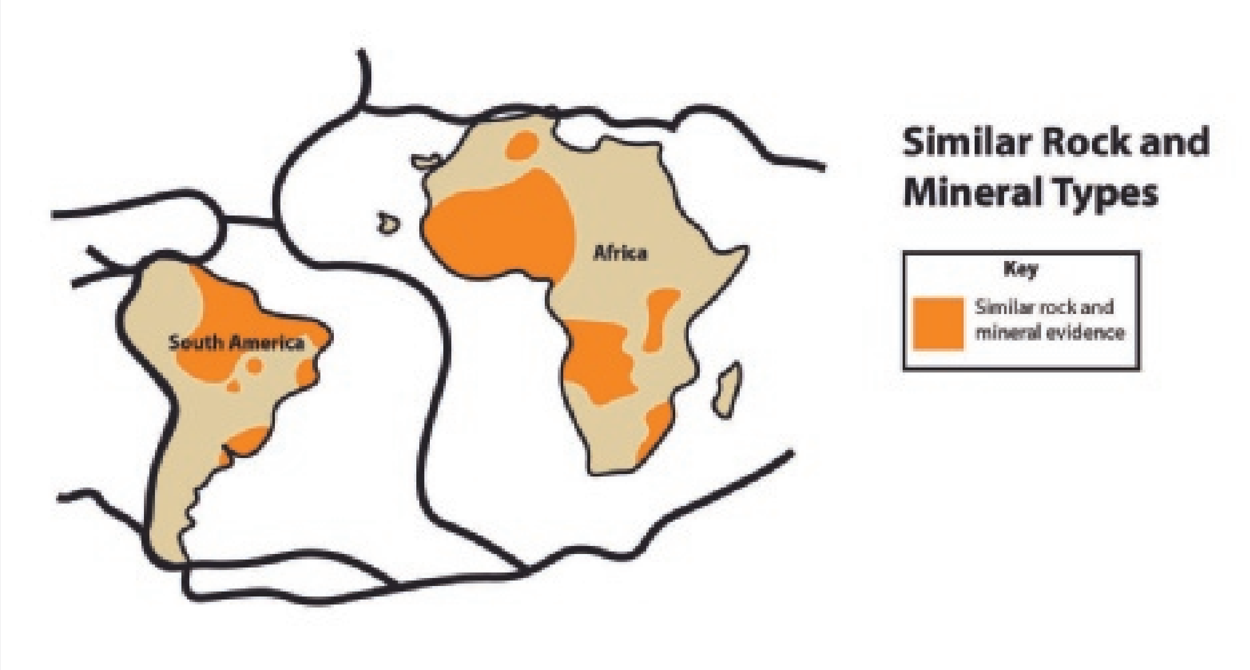
This map shows data scientists have collected about what is at and below the surface of Iceland. The orange cones are active volcanoes. The green shading is where researchers believe magma can be found below the surface. Study the map.

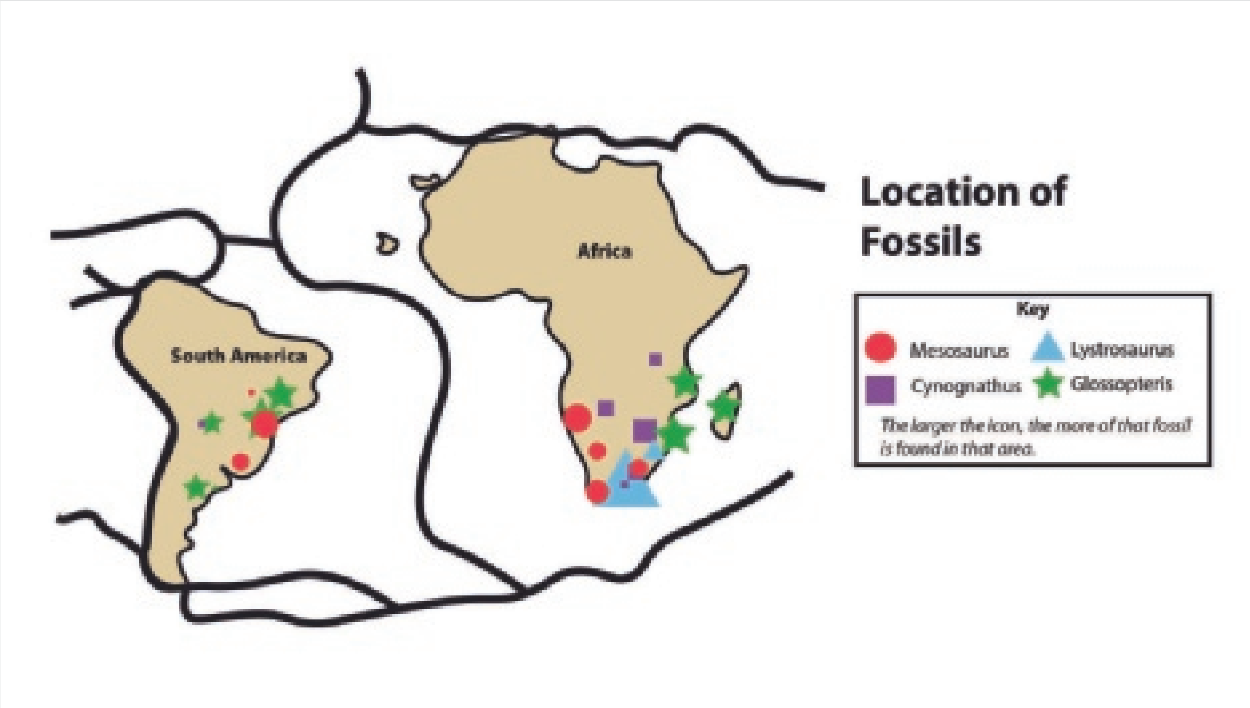
Why do you think they have found magma and volcanoes in Iceland? Does this only occur in Iceland, or does it occur in other places on the ridge as well?

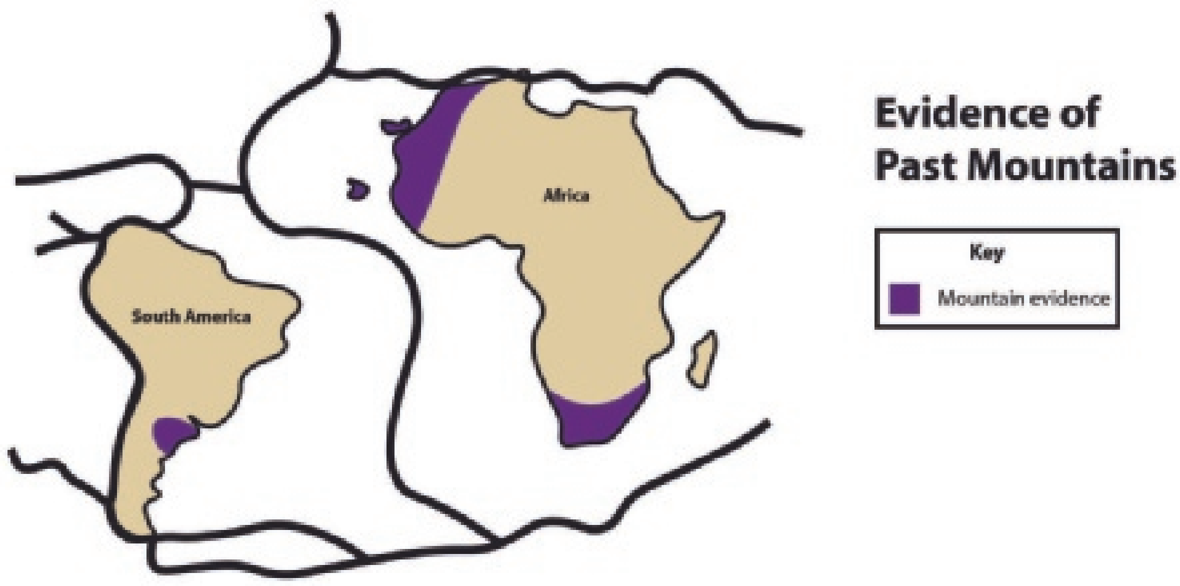


Seismic Explorer Plate Movement Map

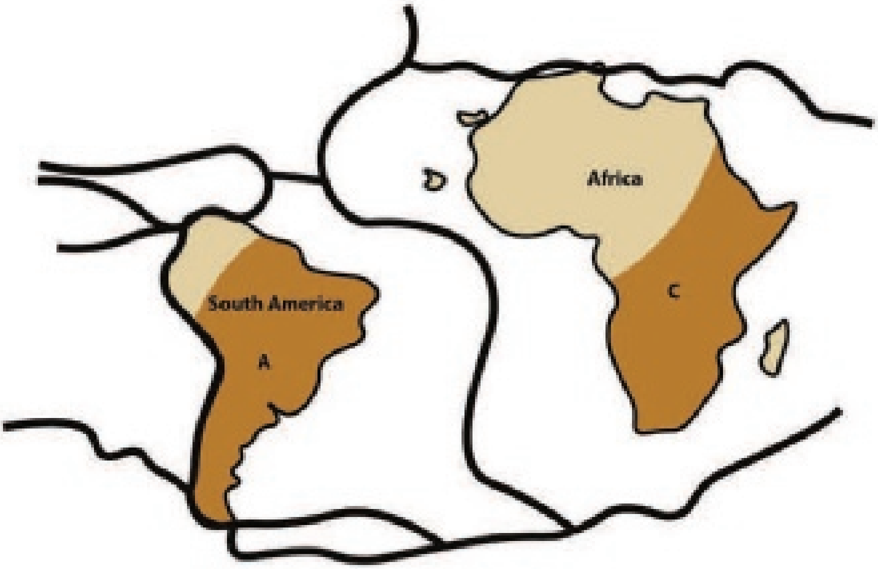
South America and Africa Evidence Maps





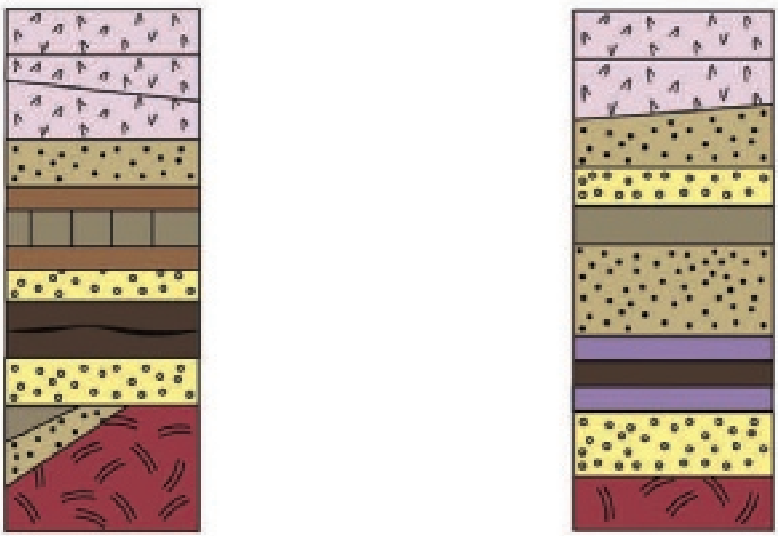

Evidence of
Past Mountains
Key
Mountain evidence
South America
Africa


Evidence of
Past Glaciers
Key
Glacier evidence
South America
Africa



Similar Rock Layers and Formations

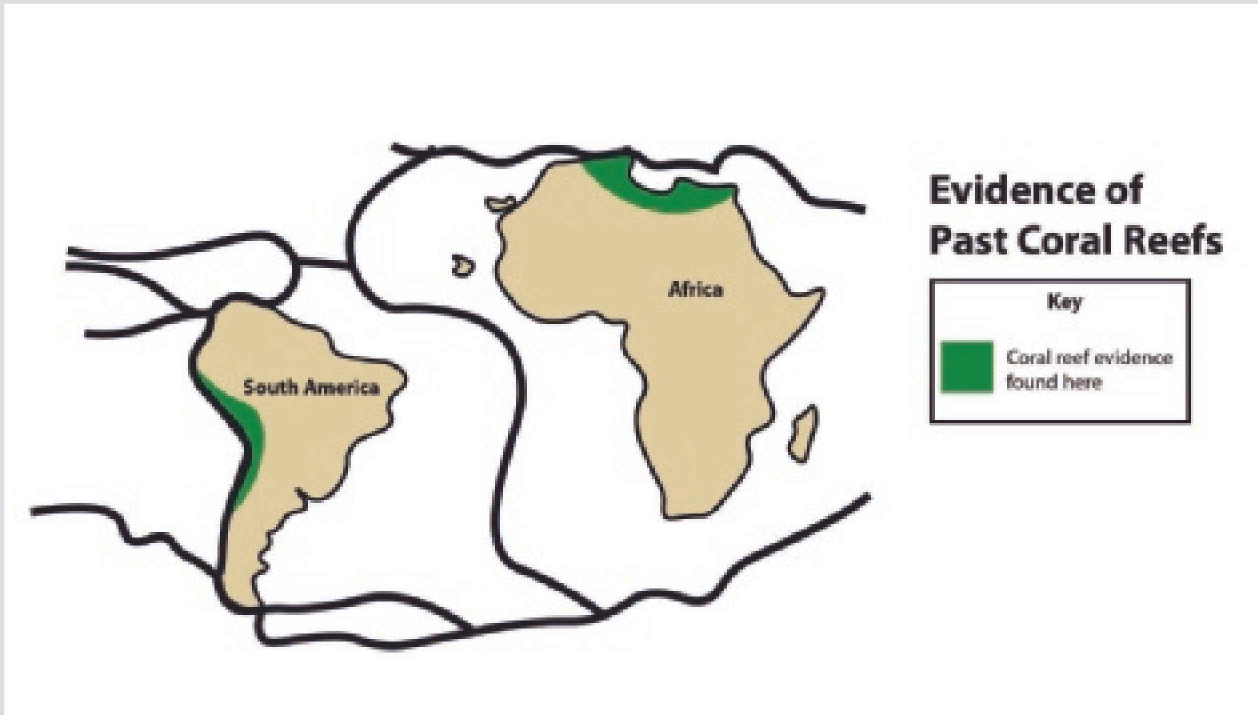
Similar Rock Layers and Formations KEY



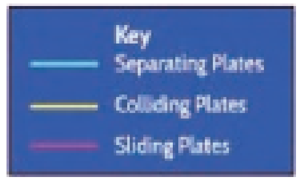
Sample A

Sample C

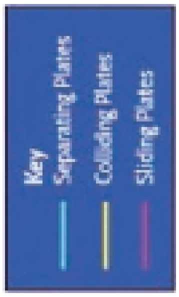
Each rock layer here is similar to the rock layers found for each section of the map.


Evidence of
Past Coral Reefs
Key
Coral reef evidence found here
South America
Africa

Satellite and Relief Maps



Mt. Narodnaya, Russia
Mt. Everest, Himalayas
Mt. Hotaka, Japan
Mt. Mitchell, North Carolina
Mt. Aconcagua, Andes
New Zealand



Key
Separating Plates
Colliding Plates
Sliding Plates

Name: ______________________________ Date: ______________________

Reading: What is happening on Mount Everest?

Mount Everest is the tallest recorded mountain in the world. It is located on the border of two countries, China and Nepal. In the past, these two countries have collected earthquake, elevation, and location data separately on their own sides of the mountain, but had not compared the data with each other to check for accuracy. Since each country was collecting separate data and not using the other country's data to check their work, this led to a disagreement on the exact height of Mt. Everest. In 2015, a massive 7.8 magnitude earthquake occurred near Mt. Everest. Areas surrounding Mt. Everest and in both countries felt the earthquake. Scientists believed that the earthquake may have impacted the height, or elevation, of the mountain. The two countries decided to share their GPS data to figure out if there were any changes to Mt. Everest due to the earthquake.

In the years that followed, Chinese and Nepalese scientists set up Global Positioning System (GPS) receivers at different places on the mountain. GPS provides the signals that our cell phones use to determine where we are located on Earth and can provide us directions to get to a new location. The GPS sensors that were used on Mt. Everest are even more sensitive than those in our phones, which enable them to detect a change in position as small as 1 millimeter.

A GPS receiver on Mount Everest. CNC Navigation

The first official measurement of Mt. Everest was reported in 1856. At that time, its peak was recognized to be about 29,002 feet above sea level. But since then, GPS data sharing between the two countries has allowed scientists to determine that Mt. Everest has increased in elevation by an average of 0.79 inches (2 cm) each year. In 2021, its peak was at 29,032 feet above sea level. In addition to these changes in height, this GPS data has also provided evidence that the peak of Mt. Everest is moving at an average of 1.6 inches (or 4 cm) a year to the northeast.

A team of scientists hiking Mount Everest. CNC Navigation

Sources:

- Camero, K. (2020). The highest point on Earth just got higher. What we know about Mount Everest's growth. *Miami Herald*. Retrieved: https://www.miamiherald.com/news/nation-world/world/article247692110.html
- Wilkinson, F. (2021). How do you MEASURE Everest? It's complicated by frostbite and politics. *Science News by National Geographic*. Retrieved: www.nationalgeographic.com/science/article/remeasuring-mount-everest-the-worlds-tallest-mo untain

Reading: Why do earthquakes happen in specific patterns around the world?

We looked at earthquake data around the world at different locations and noticed that earthquakes seem to happen in patterns, or lines, or clusters in different parts of the world. Fault lines, or cracks in the Earth's surface where there are earthquakes, happen in continuous lines mostly along mountain ranges and some occur in the middle of the ocean, but we saw some earthquakes at other spots, like Ridgecrest. Through developing a profile model of the US from the fault lines to the west to the fault lines in the Mid-Atlantic, we figured out that the large sections of land and bedrock in between these fault lines are called plates. The land that the US is on is one plate and when we looked at the world map how many plates did we think there were globally?

What could be causing earthquakes?

There have been earthquakes occurring on Earth for many years. Over time, scientists have had many different ideas for the cause of earthquakes, but some of these ideas from long ago couldn't be backed up by evidence. For example, some thought that living things under the ground caused earthquakes, while others thought the winds around the Earth were the cause for earthquakes. As scientists began recording data about what the land looked like after an earthquake, it was determined that neither could be backed with evidence.

Have you ever felt the ground move where you live? What do you think caused the ground to move?

In addition to noticing the ground shaking and moving, scientists began noticing sudden changes in Earth's surfaces resulting from these movements. In 1822, Maria Graham, a travel writer, was in Valparaiso, Chile and wrote about some of her noticings during an earthquake:

Excerpts from Maria Graham's 'Journal of a residence in Chile, during the year 1822; and a voyage from Chile to Brazil, in 1823', London, 1824

November 20th, 1822.

'At a quarter past ten [in the evening], the house received a violent shock, with a noise like the explosion of a mine. I sat still.. until, the vibration still increasing, the chimneys fell, and I saw the walls of the house open. We jumped down to the ground, and were scarcely there when the motion of the earth changed from a quick vibration to a rolling like that of a ship at sea. The shock lasted three minutes. Never shall I forget the horrible sensation of that night. [Back in the house] I observed that the furniture in the different rooms. . . Had all been moved in the same direction, and found that direction to be north-west and south-east.

Mr Cruikshank has ridden over from old Quintero: he tells us that there are large rents along the sea shore; and during the night the sea seems to have receded in an extraordinary manner, and especially in Quintero Bay. I see from the hill, rocks above the water that never were exposed before.

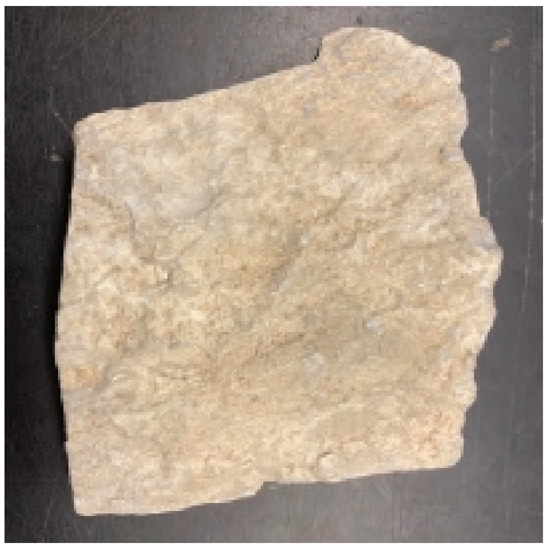
On the night of the nineteenth, during the first great shock, the sea in Valparaiso bay rose suddenly, and as suddenly retired in an extraordinary manner, and in about a quarter of an hour seemed to recover its equilibrium; but the whole shore is more exposed and the rocks are about four feet higher out of the water than before.'

December 9th, 1822.

'in the evening I had a pleasant walk to the beach with Lord Cochrane; we went chiefly for the purpose of tracing the effects of the earthquake along the rocks. On the beach, though it is high water, many rocks with beds of muscles remain dry, and the fish are dead; which proves that the beach is raised about four feet at the Herradura. Above these recent shells, beds of older ones may be traced at various heights along the shore; and such are found near the summits of some of the loftiest hills in Chile.'

Ms. Graham's account of this experience led other scientists, such as Charles Darwin, to begin collecting more data about the effects on Earth's surface when earthquakes occurred.

Some other observations scientists recorded included coastlines being elevated significantly higher after an earthquake, large crevices in the land, exposed seafloor, or measuring "seismic waves" (vibrations felt through land) using materials such as gunpowder. Scientists noticed that when gunpowder was used, the ground shook and things on the ground moved or fell over. So a few thought it would be interesting to try using gunpowder underground to simulate things underground shaking and moving. They would drill a hole into the Earth and put gunpowder into the hole. When the gunpowder was ignited they saw it caused the ground to move in vibration patterns out from the place the gunpowder was ignited. At the time, they also had a machine to collect data about the movement of the earth. Scientists would use a machine to record how the land moved and how long it took to happen. They found vibrations can travel through solid material, like rock and have characteristic patterns for how things move at the surface!! These vibrations are called ***seismic waves.*** These patterns found from using the gunpowder investigation resulted in patterns similar to what is observed during earthquakes.



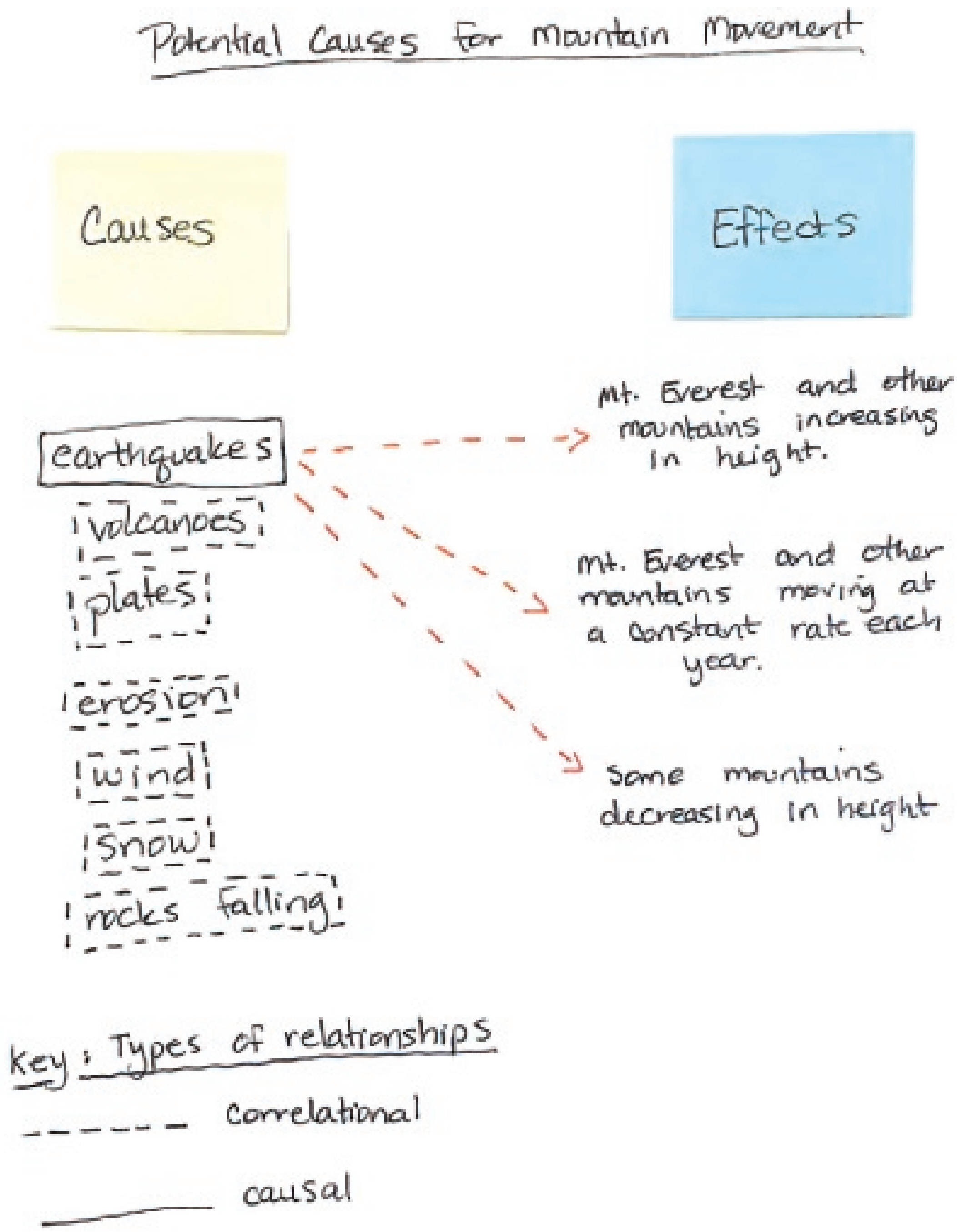
When scientists studied these earthquake patterns they noticed that they seem to happen near areas where the solid ground breaks and shifts. This got them thinking about how other solids crack, such as a ceramic dinner plate. What have you ever seen that appeared pretty solid, but then broke, like a ceramic dish?

Think about what we figured out is below the bedrock. What happens to the rock as we get deeper underground?

This led scientists to wonder how something as solid as the ground on Earth, could move like it does and break apart and/or move apart when there is an earthquake. They assumed maybe the ground that is solid can break apart and this might be happening where the earthquake lines are, and then the rest of the land is continuous and solid or unbroken.

As data was collected over time about earthquakes around the Earth and how the land was changed after an earthquake occurred, scientists determined that the surface of the Earth, called the ***crust,*** is not one solid continuous piece of rock, like originally thought. They began picturing it like the image of the broken ceramic plate above. Because of this image, scientists named these different pieces of Earth's surface, ***plates.*** Scientists today are not in agreement on how many plates there are, but most agree on 9 major plates. They debate how big of a piece of land makes a plate because there isn't enough earthquake data to clearly identify all the boundaries of different plates. In some places, it is difficult to know how to define the edges or boundaries of the plates. Think back to our broken ceramic plate - there were some really large pieces, but then there were also a lot of little chips. This is how scientists use their data they have collected to map out where these different plates are located. Where the plates touch each other, or are in contact, is called the plate boundary. One cause of an earthquake is when these plate boundaries move against each other.

Let's look back at our map. Where do you see some evidence of where the larger plate boundaries could be?



Below are the names of the 9 major plates (named after land that is on them) and some data about how the plates are moving.

Name of Plate	Average range of Speed of movement (mm/yr)	Direction moving
African	215 mm	East
Antarctic	12-14 mm	Northwest
Australian	62-70 mm	Northeast
Euroasian	7-14 mm	South
Indian	26-36 mm	Northeast
Indo-Australian	37-56 mm	Northeast
North American	15-25 mm	West
Pacific	56-102 mm	Northwest
South American	27-34 mm	West

What are some things you notice about the movement of the different plates?

Scientists create large networks of GPS receivers mostly near plate boundaries. If you saw one of these receivers, you would probably not think much of it. They generally have a small fence for protection and a solar panel to power them. They can be wireless, so they would also have a small antenna. The modern GPS receivers are almost real-time, and movement can be seen in seconds by scientists back at the lab. By using a network of receivers near plate boundaries, scientists can very accurately determine how the plates behave. Plates move about as fast as your fingernails grow.

How scientists measure earthquakes today

We read about how scientists long ago collected evidence that an earthquake has occurred, but new advances in technology continue to be developed to better measure and predict earthquakes. Scientists want to be able to predict and study earthquake to better plan for and warn people for when they might occur. Today scientists use a global network of GPS data and underground sensors to monitor movement of Earth's surface.

How is GPS data used to measure movement on Earth's surface?

Today scientists use GPS data to keep track of how the Earth is moving. Instead of just three points of satellite data to measure movement, there are 24 satellites above Earth used for collecting this data, making it very accurate. According to Incorporated Research Institutions for Seismology, each satellite consists of a computer, an atomic clock, and a radio transmitter. As satellites orbit at approximately 20,000 kilometers (12,500 miles) above the surface, they constantly broadcast their positions through the radio signals. The receivers on Earth need to connect with at least three satellites to obtain a "triangulated" position. The more satellites the receiver can use to triangulate, the more accurate the calculation becomes. Receivers placed near plate boundaries are so precise in their measurements that they can obtain the location of a receiver with error less than the size of a grain of rice!

What about Mount Everest?

In an effort to more accurately track how Mt. Everest is moving, scientists have placed 26 different GPS receivers that are secured into the rocks of the mountains along the Himalayan area. With 24 satellites circling Earth, each receiver can pick up 8 satellites and record the readings to more accurately pinpoint how the land under the receiver is moving. Scientists are also hoping that with more accurate data about Earth's movement, they may be able to more accurately predict when larger, more destructive earthquakes are going to happen and then they can warn people to prepare ahead of time. One scientist shared, "The relative motion of these points is telling us how the Himalaya is deforming", or how the Himalaya is changing shape, location and/or size. The result is clear: India is moving northward toward southern Tibet at 18 mm each year, and the high mountains are rising at an approximate average of 5mm each year.

Now, figure out which direction and speed the plates are moving at your assigned location. Use the reference, *Unknown material with identifier: pt.l3.ref,* to help locate which plates are at that location.

Sources:

Maria Graham's journal entries obtained from: https://trowelblazers.com/maria-graham/

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